DOCUMENT RESUME

ED 203 141 CE 029 276

AUTHOR	Linhardt, Richard E.; Burhoe, Steve
TITLE	Agricultural Structures. Volume I. Instructor's Guide. Volume 13, Number 1.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Education, Jefferson City. Div. of Career and Adult Education.; Missouri State Dept. of Elementary and Secondary Education, Jefferson City.
REPORT NO	AG-90-I; Agdex-710
PUB DATE	May 81
NOTE	357p.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri--Columbia, 10 Industrial Education Building, Columbia, MO 65201 ($15.00).
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Agricultural Education; Agricultural Skills; Behavioral Objectives; *Construction (Process); Curriculum; *Facility Guidelines; *Instructional Materials; *Learning Activities; *Learning Modules; Secondary Education; Tests; Vocational Education
IDENTIFIERS	Missouri

ABSTRACT

This document is a curriculum unit in agricultural structures designed to expand the curriculum materials available in vocational agriculture in Missouri. The guide consists of three units on constructing farm buildings, planning farm water systems, and building fences. Each unit contains 10-15 lessons on various aspects of the unit's topic. Each unit contains an objective, study questions, teaching procedure, discussion, assignment, exam, and answers to exam. Illustrations are used to simplify explanation of construction procedures. A reference list also is included. (KC)

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Agricultural Structures Volume 1

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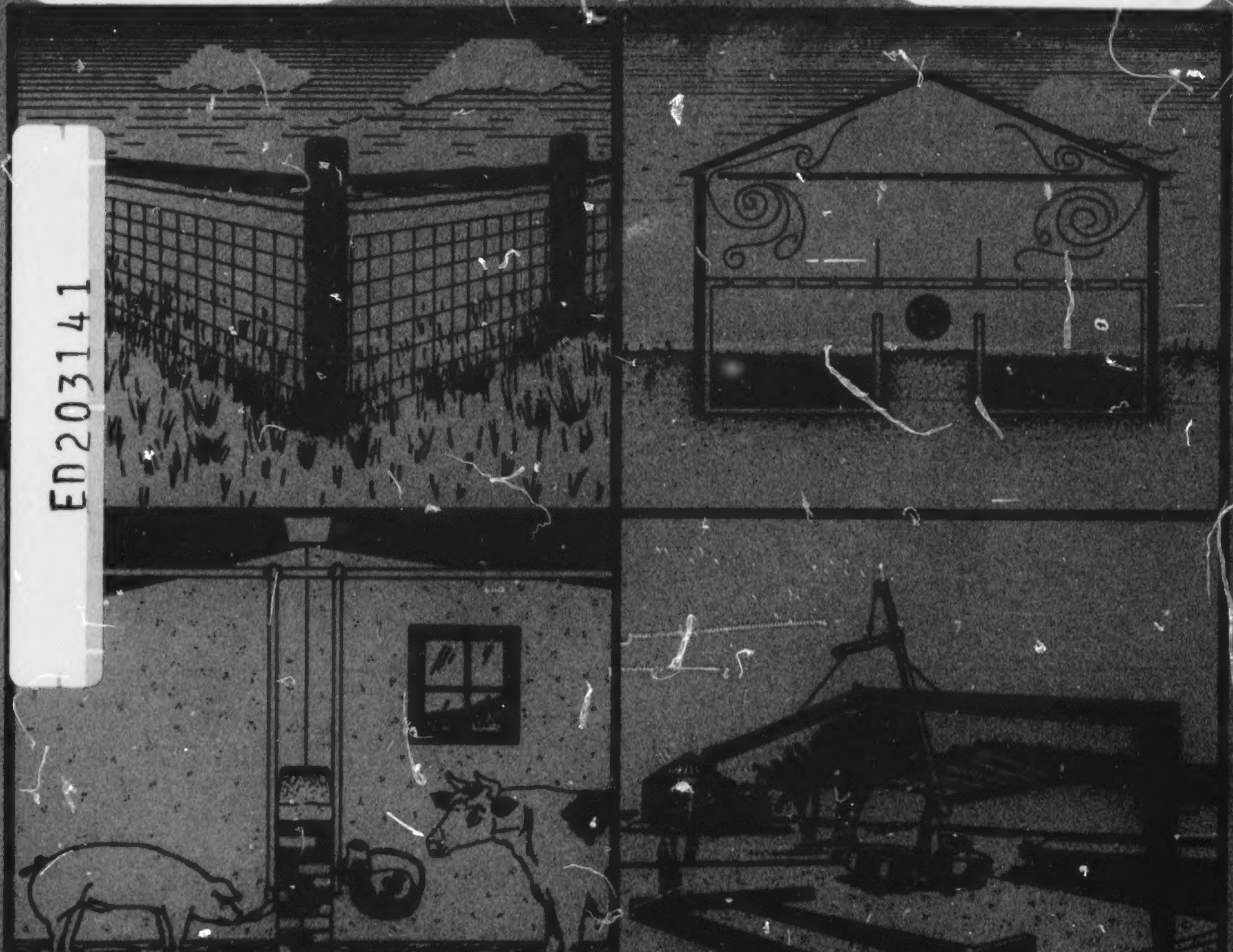

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INSTRUCTOR'S GUIDE

AGRICULTURAL STRUCTURES
Volume I

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Volume 13
Number 1

Produced by the Instructional Materials Laboratory
University of Missouri-Columbia
Columbia, Missouri

Catalog Number AG-90-I
May 1981

ACKNOWLEDGMENTS

Many individuals have contributed guidance on the content to be included in a structures unit. The MVATA Teaching Aids Committee suggested the general content of the units, and the Structures Subcommittee helped to finalize the lessons to be included in each unit.

The Agricultural Engineering Extension Division was extremely helpful in locating reference materials with special emphasis going to the Midwest Plan Service. Together with AAVIM, the MWPS materials provided the bulk of the reference materials.

Special recognition is due to Dr. Harley Schlichting, Director of the Instructional Materials Laboratory, and his staff for the typing, editing and illustrating of this guide.

FOREWORD

This curriculum unit in Agricultural Structures is an important addition to the curriculum materials available in Vocational Agriculture. This unit has been a high priority item to help expand the Agricultural Structures course currently being taught in Missouri agriculture programs.

Teachers should make every effort to keep the lessons "practical" to help students understand and become proficient in the areas of agricultural structures.

This guide and the guide to follow (Agricultural Structures II) will provide valuable reference material to systematize the structures curriculum.

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AGRICULTURAL STRUCTURES
VOLUME I

TABLE OF CONTENTS

PAGE

ACKNOWLEDGMENTS iii

FOREWORD v

BIBLIOGRAPHY xi

UNIT: CONSTRUCTING FARM BUILDINGS 1

LESSON 1: HOW IS THE FARMSTEAD PLANNED FOR MAXIMUM USE? . 1

LESSON 2: WHAT ARE THE STEPS FOR PLANNING AND PURCHASING A FARM BUILDING?. 11

LESSON 3: HOW IS THE BUILDING SITE SELECTED?. 21

LESSON 4: WHAT FASTENERS ARE USED IN THE CONSTRUCTION OF FARM BUILDINGS? 29

LESSON 5: HOW DOES THE BUILDER KEEP THE LIVESTOCK BUILDINGS WARM?. 39

LESSON 6: HOW IS THE FOUNDATION OF A FARM BUILDING LAID OUT AND THE FOOTINGS SET? 47

LESSON 7: HOW IS THE FLOOR FRAMED IN A FARM STRUCTURE?. . 57

TM-1: Types of Framing. 71
TM-2: Floor Members 73
TM-3: Joists Used in Platform and Balloon Framing . . . 75
TM-4: Lap Joists. 77
TM-5: Beam Ledger and Framing Anchor Joists 79

LESSON 8: HOW ARE WALLS FOR FARM BUILDINGS CONSTRUCTED? . 81

LESSON 9: HOW ARE TRUSSES DESIGNED AND CONSTRUCTED? . . . 89

TM-1: Parts of a Truss. 97
TM-2: Plywood Grade Stamps. 99
TM-3: Heel Gusset 101
TM-4: Different Types of Gussets. 103
TM-5: Splices 105
TM-6: Truss Jig 107
TM-7: Nailing Diagram 109
TM-8: Windbracing 111
TM-9: Truss Anchorage 113

HO-1: Summary Page. 115
HO-2: Ceiling Construction. 117

LESSON 10: WHAT ROOFING MATERIALS ARE COMMONLY USED AND HOW ARE THEY ATTACHED? 119

LESSON 11: HOW ARE FARM UTILITY BUILDINGS CONSTRUCTED?. . 127

LESSON 12: WHAT ARE THE FACTORS TO CONSIDER WHEN PLANNING SWINE HOUSING AND EQUIPMENT? 137

LESSON 13: HOW IS BUILDING LUMBER MADE AND SELECTED FOR USE IN FARM STRUCTURES?. 149

LESSON 14: WHAT ARE THE PLANNING AND DESIGN FACTORS OF BEEF HOUSING AND EQUIPMENT?. 165

TM-1: Cattle Flow 175
TM-2: Processing and Mixing 177

LESSON 15: HOW IS A POLE OR POST BUILDING CONSTRUCTED?. . 179

TM-1: Post Building With Trusses. 189
TM-2: Pole Building With Common Rafters 191
TM-3: Building Layout 193
TM-4: Aligning and Bracing Poles. 195

UNIT: PLANNING FARM WATER SYSTEMS 201

LESSON 1: HOW ARE THE WATER NEEDS CHECKED AGAINST AVAILABLE SUPPLY?. 201

LESSON 2: WHAT IS NEEDED TO PROVIDE SAFE WATER? 209

LESSON 3: HOW IS THE NEED FOR WATER CONDITIONING DETERMINED?. 219

LESSON 4: WHAT METHODS OF WATER CONDITIONING ARE AVAILABLE? 227

LESSON 5: HOW IS THE TYPE OF PUMPING INSTALLATION DETERMINED? 235

LESSON 6: HOW IS THE PIPING INSTALLATION PLANNED? 247

LESSON 7: HOW IS THE ELECTRICAL INSTALLATION PLANNED? . . 255

UNIT: LIVESTOCK WASTE MANAGEMENT. 269

LESSON 1: WHAT IS WASTE DISPOSAL? 269

LESSON 2: WHAT ARE THE CHARACTERISTICS OF ANIMAL WASTES?. 277

LESSON 3: HOW ARE LIVESTOCK WASTES COLLECTED ON THE FARM? 287

LESSON 4: HOW IS RUNOFF COLLECTED ON THE FARM?. 295

LESSON 5: HOW ARE GUTTERS FLUSHED? 303

LESSON 6: WHAT STORAGE METHODS ARE AVAILABLE FOR ANIMAL WASTE? 311

LESSON 7: HOW ARE THE SOLIDS AND LIQUIDS SEPARATED? . . . 319

LESSON 8: WHAT METHODS OF BIOLOGICAL TREATMENT ARE AVAILABLE? 327

LESSON 9: WHAT METHODS ARE AVAILABLE FOR TRANSPORTING WASTE? 337

LESSON 10: HOW WILL END PRODUCTS OF LIVESTOCK WASTES BE EFFECTIVELY AND PROFITABLY UTILIZED ON THE FARM 347

UNIT: BUILDING FENCES 361

LESSON 1: HOW DO I LAY OUT AND CLEAR FENCE LINES? 361

LESSON 2: HOW DO I INSTALL BRACES AND POSTS? 369

TM-1: Anchor and Brace Assembly 377

LESSON 3: HOW DO I BUILD BARBED WIRE AND WOVEN WIRE FENCES? 379

LESSON 4: HOW DO I BUILD ELECTRIC FENCES? 387

TM-1: Electric Gate 395

LESSON 5: HOW DO I BUILD CABLE FENCES? 397

TM-1: Cable Fence 403

LESSON 6: HOW DO I BUILD WELDED-WIRE PANEL FENCES? 405

LESSON 7: HOW DO I BUILD BOARD FENCES? 413

LESSON 8: HOW DO I BUILD WOOD RAIL FENCES? 421

LESSON 9: HOW DO I BUILD CHAIN LINK FENCES? 429

LESSON 10: HOW DO I BUILD GATES? 437

TM-1: Metal Gates 445
TM-2: Wood Gate 447
TM-3: Temporary Gate 449

9

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UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 1 - How is the farmstead planned for maximum use?

Objective: Upon the conclusion of the lesson, students will be able to identify the essential factors of a plan, to identify planning factors as a part of the layout, and to establish wind and snow controls.

Study Questions:

1. What are the essential factors to a farm plan?
2. What "tools" make a good farm plan?
3. How are zonal plans used in farmstead development?
4. What planning factors are part of the layout?
5. How are activity centers planned?
6. What planning considerations are needed for machinery, fuel, chemical, fertilizer, and grain storage?
7. What planning considerations are needed for livestock?
8. How is wind and snow controlled?
9. What symbols are used in farmstead design?

Reference:

1. Structures and Environment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $5.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 1 - How is the farmstead planned for maximum use?

TEACHING PROCEDURE

A. Review

B. Motivation: How is the farmstead laid out for maximum efficiency and use? What factors go into the plan? How can the weather affect heating and cooling costs?

C. Assignment: Have each student construct a one-dimensional drawing of their home farm, including machinery and labor flow.

D. Supervised Study: Develop a model farm plan in class. Design model for maximum efficiency and use of machinery and buildings.

E. Discussion

1. There are four critical factors in the development of a farmstead plan. List them on the board.

   What are the essential factors to a farm plan?

   1) Water of reasonable quality and quantity is essential.
   2) Surface and subsurface drainage has top priority.
   3) Plan for production volume in addition to the current space needed.
   4) Off-farm factors of urban and suburban developments, zoning codes, and pollution regulations are also essential factors to a farm plan.

2. A good farm plan takes careful planning. A great deal of time and effort goes into a well-developed plan. Here are some "tools" you need to accumulate.

   What "tools" make a good farm plan?

   1) Goals and priorities
   2) Mechanical drawing equipment
   3) Inventory map of farm area, topography, and current operating buildings
   4) Information on needed facilities, utilities, traffic, feed handling, and taxes
   5) Aerial photographs
   6) Contour maps

3. Zonal planning involves laying out distances from the central farm housing using 100-foot zones. This method is advantageous for planning future growth, efficiency, and sale value of the property.

   How are zonal plans used in farmstead development?

   1) Draw circles 100 feet apart using the house as center.
   2) Zone 1 is the family living lawn and garden, protected from noise, odor, and dust.
   3) Zone 2 is the machinery center--relatively quiet, dry, and odor free. Fuel and chemical storage are on fringe of zone 2.
   4) Zone 3 is for grain, feed, and some livestock, which causes dust, noise, traffic, and odors. This zone needs vehicle access and electric power. Maternity and nursery area should be near the house.
   5) Zone 4 is for major livestock facilities which create a demand for adequate space, drainage, waste management, access, loading facilities, feed distribution, and other services. An outer circle allows for expansion.
   6) It is easier to move away from the homestead.

4. Planning factors are points which help distinguish between trouble parts of the farm plan. All of the factors mentioned here are important to consider in the long range planning of the farm facility. Discuss each factor in detail with examples in your community.

   What planning factors are part of the layout?

   1) Distance factors help locate one activity relative to other activities.
      a) Management is determined by the need for closeness to home, age of animals, or need for accessibility to other facilities and livestock.
      b) Size of enterprise determines facility placements. Spread-out farms require more management.
      c) Pollution of air or water should be kept from home area and neighbors.
      d) Nuisances such as noise, dust, and insects should be away from central living areas.
      e) Appearance of a well laid-out farm is not only attractive but efficient.
   2) Topographic factors--"the lay of the land"
      a) Site selection: By rule of thumb the best place available to consider is the largest area you may need and double it for expansion.

b) Drainage surface and subsurface flow of water should be away from structures.
c) Slope ideal of drainage surface is 2% to 5% so that erosion problems do not arise.
d) Allowance for subsurface drainage for underground structures should be considered.
e) Enough space for activities and expansion should be planned.

3) Climatic factors may be minimized by proper design and arrangement of buildings.
  a) Wind
  b) Sun
  c) Rain and snow

4) Service factors linking buildings, activities, and public roads should be considered.

5) Locate and label utilities. Locate existing lines and load as to type, size, and depth of each.
  a) Water
  b) Electricity
  c) Gas
  d) Telephone
  e) Fire protection
  f) Security with alarms and lights

5. What must be considered when planning work areas? Loading areas? Repair areas? Living areas? Plan each carefully using the following guidelines.

How are activity centers planned?

1) Family living center includes yard, garage, etc.
2) Essential factors of water, drainage, and site location are planned.
3) Special factors are considered, such as the house overlooking the farm entrance and the farm office located on the farm entrance side of the house.
4) Distance factors concerning odors and accessibility to facilities are regarded.
5) Topographic factors such as a space for visitors to park and a good view of the road and farm from the house are proposed.
6) Climatic factors such as a tree windbreak to catch snow, located 185 feet from first tree to house, are delineated.
7) Service factors include planning drives and parking.

6. The placement of storage facilities is a serious concern to the farm planner. Where do these facilities go? What planning factors are involved?

What planning considerations are needed for machinery, fuel, chemical, fertilizer, and grain storage?

1) Machinery storage and the farm shop need to be located close together, easily accessible to the house. Provide a 40- to 50-foot service area in front of the shop for repairs.
2) Locate fuel storage 50 feet from the shop to allow machinery to move easily. Provide a hard surface (not asphalt as gas will dissolve asphalt) or gravel on a sloped surface to allow water drainage.
3) For convenience, chemical storage should be away from the house on the far side of the shop for safety from children. The building should be properly ventilated and an emergency wash area set up.
4) Grain center needs electricity, vehicle access, room for expansion, drainage, and proximity to livestock feeding area.
    a) Grain center needs drainage for all weather loading and unloading.
    b) Locate grain center in zone 3 because of dust, noise, and the need for the room to move large trucks.
    c) Need good surface and subsurface drainage for a solid road.
5) Be sure roads, bridges, and culverts can handle the vehicle weights.

7. Do livestock require special planning decisions? What differences can be found between grain and livestock operations?

What planning considerations are needed for livestock?

1) Waste disposal regulations and management are drafted.
2) High water demand for consumption by livestock or cleaning is resolved.
3) Good controlled drainage is designed.
4) Odor control is outlined.
5) Locate where expansion would be easy and accessible to feed facilities.
6) Power demand for confinement is projected.

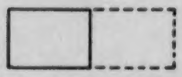
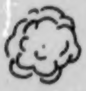
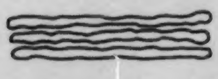
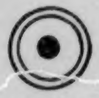
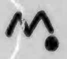
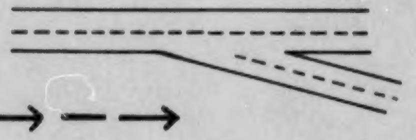
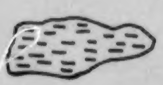
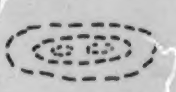
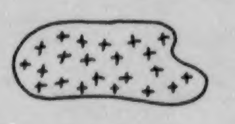
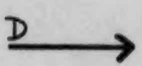
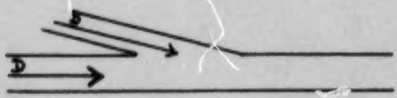
8. Wind and snow can cause severe damage to farm structures if not properly controlled. What less serious expenses can they cause?

How is wind and snow controlled?

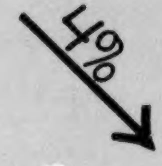
1) The best control is windbreaks--generally trees and shrubs located in the line of prevailing winter winds.
2) Missouri winds in January tend to blow from the northwest.
3) Tree windbreaks 150 feet long and 20 feet apart cut wind velocity protecting an area 10 tree heights when placed upwind to the farmstead. Example: Trees 15 feet high, protect 150 feet.
4) Windbreak fences are for short distance protection. A 10-foot fence on a 4-foot ridge can protect a 200-foot wide feed lot.
5) Sun helps dry surfaces and heat in winter.
6) Proper overhang will shade in summer when sun is high and heat in winter when sun angle is low.

9. Draw a map with the symbols in the reference; then have the class complete a map for a farm in the area.

What symbols are used in farmstead design?

1) Buildings 
2) Trees 
3) Windbreaks 
4) Well 
5) Meter pole 
6) Roads and drives 
7) Traffic flow ——→ ——→
8) Low, poorly-drained land 
9) High, well-drained land 
10) Pond 
11) Drainage 
12) Waterways or ditches 

13) Direction and percent slope



F. Summary

The completion and implementation of a well-designed plan will provide a lifetime of trouble-free movement of supplies and livestock. If done properly, expansion can be done with a minimum of disruption to the remainder of the operation.

G. Evaluation

Answers to Exam

1. a. Quality and quantity of water
   b. Surface and subsurface drainage
   c. Plan for current production
   d. Off-farm factors
2. a. Zone 1 is the family living lawn and garden, protected from noise, odor, and dust.
   b. Zone 2 is the machinery center--relatively quiet, dry, and odor free.
   c. Zone 3 is for grain, feed, and some livestock.
   d. Zone 4 is for major livestock facilities.
3. a. Management
   b. Size of enterprise
   c. Pollution of air or water
   d. Nuisances
   e. Appearance
4. F
5. T

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 1 - How is the farmstead planned for maximum use?

EXAM

1. What are the four critical factors of a farm plan?

   a.

   b.

   c.

   d.

2. What are the four zones of the farmstead plan?

   a.

   b.

   c.

   d.

3. What are the five planning factors to consider?

   a.

   b.

   c.

   d.

   e.

T F 4. In order to make work easier the shop should contain the fuels, oils, and chemicals all under one roof.

T F 5. A good tree windbreak will protect the farmstead from a heavy blowing snow.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 2 - What are the steps for planning and purchasing a farm building?

Objective: Upon the conclusion of the lesson, students will be able to list and discuss the twelve steps of planning and purchasing a farm building.

Study Questions:

1. How is the site selected?
2. How is the size and layout determined?
3. How is the type of foundation selected?
4. How are the specifications set?
5. What will determine whether to purchase a complete building or to build it yourself?
6. How is a builder selected?
7. Should the farmer see an example of the building before he/she buys it?
8. How are sales proposals evaluated?
9. How are buildings evaluated?
10. How are warranties evaluated?
11. What about financing and insurance?
12. What is the first and the last step of planning and purchasing farm buildings?

Reference:

1. Step-By-Step, How to Plan and Purchase a Farm Building, by Butler Manufacturing Company, Agri-Products Division, 740 East 13th Street, Kansas City, MO 64126 Form No. 3996 Free

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 2 - What are the steps for planning and purchasing a farm building?

TEACHING PROCEDURE

A. Review

B. Motivation: Invite a speaker to class from one of the local building companies that specializes in farm structures. Discuss costs and time of contracted or self-built structures.

C. Assignment: Have students call local farm builders to compare the prices of the buildings the builders sell.

D. Supervised Study: Develop a plan of attack for site selection and purchase of buildings in your area.

E. Discussion

1. Discuss different types of terrain and how they can cause trouble for the builder.

   How is the site selected?

   1) Keep buildings close together to save steps.
   2) Leave enough distance between buildings to easily turn and park machinery.
   3) Consider topography to cut leveling costs.
   4) It is cheaper to level before construction than after construction.
   5) Consider the sun and wind exposures; southern or eastern is best.
   6) Always consider
      a) Slope
      b) Drainage
      c) Wind direction
      d) Relation of buildings to one another, fields, and roads

2. Always plan for more than you need to allow for growth. Measure the size of equipment (combines, tractors, etc.) and calculate storage needs.

   How is the size and layout determined?

1) How big? "Bigger than you need now!"
2) Build wider, taller buildings with larger doors than now needed.
3) Check out other buildings in your area; profit from their experience and mistakes.
4) Park the machinery on the site and stake out dimensions before building.
5) Rectangular buildings with large centered end wall doors work well.
6) Use grid paper to develop plan needs.
7) Plan freely for a large area to repair equipment.
8) Study a combination building of machinery and grain storage. (Watch wall strength from the added load.)
9) Review plans already developed by Extension Departments or other groups.

3. Discuss the floor differences that can be found in a farm shop, i.e. concrete, dirt, stone.

How is the type of foundation selected?

1) Look at strength, versatility, and usefulness.
2) Foundation must hold the building down as well as up.
3) Foundation must keep out water, rodents, wind, and rain.
4) Concrete is the best buy in foundations.
5) Perimeter foundation is most economical when only machinery is to be stored.
6) Slab foundation is more expensive, but it is better for shops or grain storage. A slab foundation protects objects from moisture and is the best working surface for a farm shop.
7) A slab foundation should be a minimum of 5 inches thick and should be reinforced.

4. Determine the specifications for a small building. List the possible loads on the board and discuss where the strength is needed.

How are the specifications set?

1) Develop your own specifications before seeing a builder.
2) Try to use standard dimensions to cut costs.
3) Consider wind and snow loads; consult American Society of Agricultural Engineers (ASAE) through the nearest Extension Service.

4) Insist that the specifications be met when bids are made by builders.
5) Consider lighting and ventilation.
6) Your best protection against inferior building design is an engineer's seal on all plans.

5. Discuss the amount of time needed to complete a building and the time it would take you away from the job.

What will determine whether to purchase a complete building or to build it yourself?

1) The farmer has three alternatives:
    a) Build it himself/herself.
    b) Have the dealer supervise your labor.
    c) Have the dealer build it.
2) Factors to consider
    a) Cost of labor
    b) Your construction skill
    c) Value of your own time
    d) Quality of workmanship required
    e) Building design: Is it just bolted together? Panelized?
3) Check the construction manual for each building for completeness and preciseness.
4) Factors to consider if the farmer does decide to do it himself/herself.
    a) Are special tools needed?
    b) Will the dealer help check for missing parts?
    c) Will the dealer advise on construction?
5) The value of the structure is only as good as the material and workmanship that goes into it.

6. Make a list on the board of good and bad points of the builder. Have the class rank the points from most important to least important in each category.

How is a builder selected?

1) The builder should:
    a) Assist you with building plans
    b) Discuss feasibility of specifications
    c) Provide counsel on site selection, foundation, and building design
    d) Provide service after the sale
2) Deal with an established, reputable farm building company.

3) Investigate the work of the builders.
    a) Check the Better Business Bureau.
    b) Contact Soil Conservation Service or Production Credit Association.
4) Avoid companies with fancy sales programs.
5) Be wary of fraud and bait and switch tactics.
6) Look for quality and performance of materials.
7) Ask for a written proposal (bid) which specifies everything according to requirements.
8) Ask for references.
    a) Customer
    b) Credit

7. Visit jobs that were completed in the area by the different builders. It will pay to see a completed job and talk to the owner before making a final selection.

Should the farmer see an example of a building before he/she buys?

1) Do not purchase a pig-in-a-poke; see the building before purchase.
2) Always ask to see an example.

8. Get an example of the sales proposal for a farm building and go through it step by step with the class. Ask the following questions of the class.

How are sales proposals evaluated?

1) Is the proposal complete?
    a) All materials, foundations, insulation
    b) All labor, subcontractors, accessories
    c) All cost, freight, taxes, finance charges
2) Does it meet original specifications?
    a) Square or cubic feet
    b) Usable storage area
    c) Actual vs. nominal dimensions
    d) Are the wind and snow loads certified?
    3) "R" value of insulation
3) Are the costs and dates realistic?
4) Will builder be responsible for work subcontracted?

9. Arrange to have on hand examples of fasteners, gussets, joints for metal, and sealants. Show the quality of each and how to look for strength and sealing ability.

How are buildings evaluated?

1) Always keep in mind the basic use of the building.
2) Steel buildings
    a) Concrete foundation should be reinforced.
    b) Frame should be anchored with anchor bolts set in concrete.
    c) Steel buildings should have seal of Registered Professional Engineer.
    d) An all-bolted or rigid frame eliminates field welding with maximum structural strength.
3) Wall and roof panels are precision rolled.
    a) Look for deep corrugations.
    b) Look for a snug fit between panels.
    c) Design calls for side and end lap sealant.
    d) Wall panels should be mitered at top for a tight fit.
    e) Flashing should be used over seams.
4) Look for a tight fit at the foundation.
5) High strength bolts in frame can be identified by three slashes on bolt head.
6) Use neoprene washers for better protection.
7) Do doors and windows close properly?
8) Are ventilators watertight?
9) Is insulation properly installed?

10. Have an example of a warranty to show to the class. Discuss the major parts.

How are the warranties evaluated?

1) Does it provide assurance that the building is quality designed and built to perform the duty intended.
2) First, look at what is warranted and the significance of it.
3) Second, is the warranty limited by time? Is it prorated?
4) Finally, is there a performance warranty? Who will be doing the repairing?

11. Invite a local PCA or FLB representative to speak to the class on financing a farm building. An insurance agent would also help to introduce this section.

What about financing and insurance?

1) First source of finance should be your local lender with whom you have dealt previously.
2) Investigate sources.
    a) Production Credit Association
    b) Agricultural Stabilization and Conservation Service (ASCS)

   - c) Company building the structure
3) Down payments range from 15% to 30%.
4) Progressive payments are made to the builder during construction.
5) It is customary to hold 10% of cost until the building is satisfactorily completed.
6) Shop for your money.
7) Shop for insurance locally.
8) Be sure the building is insured before delivery.

12. This step serves as a summary of the lesson.

What is the first and the last step?

1) Before building, compare and investigate all the factors. There is an advantage to selecting a company that has built a good reputation for manufacture and sale of an honest product. The best way to know what you're buying, before you buy, is to know the company from which you are buying.

F. Summary

There are twelve basic steps in planning and purchasing prefabricated structures. These were developed to provide a guideline for evaluating a builder and his/her product.

G. Evaluation

Answers to Exam

1. F
2. T
3. T
4. F
5. T
6. F
7. T
8. a. Credit
   b. Customer
9. a. Concrete foundation should be reinforced.
   b. Frame should be anchored with anchor bolts set in concrete.
   c. Steel buildings should have seal of Registered Professional Engineer.
   d. An all-bolted or rigid frame eliminates field welding with maximum structural strength.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 2 - What are the steps for planning and purchasing a farm building?

EXAM

T F 1. Buildings should be situated to face the north to provide maximum shade.

T F 2. Always plan for more than you currently need.

T F 3. Concrete is the best flooring for farm buildings.

T F 4. Specifications should be developed by the contractor before asking for bids.

T F 5. Time is the main limiting factor for the farmer when deciding whether to build for himself/herself or to contract the building.

T F 6. The best source of builders is newspaper ads.

T F 7. The proposals (bids) should be checked to meet all specifications of the plans.

8. Two references should be required of a builder. They are:

a.

b.

9. Describe a well-constructed steel building.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 3 - How is the building site selected?

Objective: Upon the conclusion of the lesson, students will be able to list and describe the factors associated with site selection.

Study Questions:

1. What surface factors influence the selection of a building site?
2. What utilities will influence the selection of a building site?
3. How is the structure site planned for convenience and labor efficiency?
4. How is weather protection included in the site selection?
5. How is the site of individual buildings determined?

References:

1. Planning Machinery Protection, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $2.25
2. Structures and Environment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $5.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 3 - How is the building site selected?

TEACHING PROCEDURE

A. Review

B. Motivation: Are all the building entrances on your farm easily accessible? Do the roads to the machinery storage on your farm get muddy and difficult to travel in bad weather? How would you improve the location of your buildings if you could move them?

C. Assignment: Draw a farm map layout of each student's farm and have the class discuss the advantages and disadvantages of each map.

D. Supervised Study

E. Discussion

1. Where do you put the building? What characteristics of the land need to be considered?

   What surface factors influence the selection of a building site?

   1) What amount of land clearing is needed? Trees or shrubs?
   2) How is the contour of the land in relation to the type of buildings planned?
      a) Low slope is best for a farm shop as there is less leveling.
      b) Variable slope is good for loafing sheds.
      c) Slope should be in relation to farmstead drainage.
   3) Elevation of site should be in relation to the usage of the area.
      a) Manure storage should be below the building.
      b) Drain by gravity.
   4) A building site should have natural protection from wind and weather.
   5) Quality of the soil must be good enough to hold poles or foundation.
   6) Location and type of other buildings are determined by surface factors.
   7) Water table level influences location of structures.

2. The location of the farm structure can also be dependent on the cost of supplying utilities. What are the costs of running electric lines

or water lines per foot?

What utilities will influence the selection of a building site?

1) Electricity accessibility should be close to the source for the farm. Long runs cause power loss.
2) Waste drainage for confinement structures should be close to the holding or spreading areas.
3) Water supply should be easily accessible or you should make plans for a separate system.
4) Is natural or propane gas a source for heating?

3. What factors affect planning for convenience and efficiency? How can preplanning save you time and money?

How is the structure site planned for convenience and labor efficiency?

1) Locate structure at a point on the farmstead easily accessible by farm equipment.
2) Locate structure at a point easily accessible to utilities.
3) If machinery is used with the structure, select a location with plenty of room for turning machinery around.
4) Allow room for expansion.
5) Select a spot accessible to the main road.

4. How is the site plan affected by the weather? Which weather factors should be considered?

How is weather protection included in the site selection?

1) If there is a problem with blowing snow or rain, point one end of the site plan into the prevailing wind.
2) If one end is closed, point that end into the wind.
3) In cold areas, close the northwest side of the buildings for maximum protection.
4) If you are in a high wind area, reinforce the walls and the roof to compensate for wind pressures.
5) Trees and hedges can be used to control wind and snow forces and can reduce heating costs and erosion. Locate trees and hedges on the north and west sides of the farmstead.

5. How do you decide where to locate different types of structures? What factors need considering in each type?

How is the site of individual buildings determined?

1) Livestock buildings should be located down wind from farmstead to reduce odors, manure problems, and insects. Winds prevail from the northwest in January and from the south in July.
2) Machinery and shop area should be located near the house for convenience.
3) Plan an open service area of 125 by 150 feet.
4) Separate buildings 50 to 100 feet to prevent fires from spreading easily.
5) Locate windows and skylight panels on the south side of buildings to take advantage of the sun.
6) If a totally new set-up is planned,
    a) Have a complete layout drawn in advance.
    b) Check all surface factors and utility concerns.
    c) Divide your working areas for ease of handling: house, machinery, grain and feed storage, and livestock.
    d) Plan for expansion needs.
    e) Plan driving areas for convenience.
7) Expansion plans
    a) Expansion plans should consider accessibility to and adequacy of utilities.
    b) Expansion plans should consider the slope of the land.
    c) Expansion plans should consider the prevailing winds for sites for windbreaks and for minimum reception of odors.
    d) Expansion plans should consider the machinery accessibility.
    e) Any expansion should be accessible to the main roads.

F. Summary

The selection of a building site has many criteria to meet. Utilities and convenience are two factors which must be considered in the planning of a building and its location. Surface factors such as slope and water table are important when planning for drainage and waste disposal.

G. Evaluation

Answers to Exam

1. Any five of the following:
    a. Amount of land needing to be cleared
    b. Contour of the land in relation to the type of buildings planned
    c. Elevation of site in relation to the usage of the area
    d. Natural protection from wind and weather
    e. Quality of the soil good enough to hold poles or foundation
    f. Location and type of buildings other than house
    g. Water table level
2. Any three of the following:
    a. Electric
    b. Gas
    c. Waste
    d. Water
3. T
4. T

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 3 - How is the building site selected?

EXAM

1. List five surface factors that will affect the selection of a building site.

   a.

   b.

   c.

   d.

   e.

2. Name three utilities considered in site selection.

   a.

   b.

   c.

T F 3. The major weather protection planned for in construction is wind.

T F 4. The proper location of trees and shrubs will produce heat savings in winter.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 4 - What fasteners are used in the construction of farm buildings?

Objective: Upon completion of the lesson, students will be able to identify proper fasteners available for a certain usage; select the correct adhesive, bolt, or nail for the job; and properly join woods together with all three methods.

Study Questions:

1. What are the groups of fasteners and the uses of each group?
2. What are the factors to consider when selecting the proper nails?
3. What are adhesives, and what are their uses?
4. When are bolts and split ring connectors used, and how are they used properly?

References:

1. Structures and Environment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $5.00
2. Practical Farm Buildings, available through The Interstate Printers and Publishers, Inc., Danville, IL 61832 $7.95
3. Pole and Post Building Construction, by NRAES, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $1.50

TEACHING PROCEDURE

A. Review of basic shop skills would be helpful.

B. Motivation: Attach several boards together using nails, bolts, and glue; then try to break them apart. Use several different types of each fastener.

C. Assignment: Gather as many different types of fasteners as can be found around a farm. Compare what each student has found at home.

D. Supervised Study: Have the students demonstrate their proficiency in attaching woods together; then discuss the results.

E. Discussion

1. To understand the strength of a structure, each person must know how and why the various parts are joined together. Fasteners join parts together to produce the walls, trusses, and ceiling of a farm structure.

   What are the groups of fasteners and the uses of each group?

   1) Farm structures are built using three primary fasteners: nails, bolts, and glue. Each of these fasteners have their uses and strengths, and they must be used properly if you expect to have a secure structure.
   2) Nails are the most commonly used of the three fasteners and come in a wide array of shapes, sizes, and uses. (Rules for their use will come later.)
   3) Bolts provide strength superior to a nail, but they require more labor to install than nails.
   4) Glue joints can be as strong or stronger than the structure members themselves; but flaws in joints are difficult to determine. Glue joints take longer to adhere than other fasteners and need ideal conditions in which to work properly. They are often used in combination with other fasteners, unless the situation requires "blind" joining (joining with no protrusions or outside marks).

2. The method most used and the easiest to accomplish is nailing. The point to remember is that no nail can do all the jobs, so take care to select the proper equipment.

   What are the factors to consider when selecting the proper nails?

   1) Most buildings used on the farm are now constructed of pressure treated lumber because of the ability of this wood to resist moisture, disease, and insects. Problems begin because the treatment used to preserve the wood makes it harder for the nails to hold in the lumber. Creosote, nalpha and other preservatives have a lubricating effect on fasteners. To counteract this action, spiral or screw shank nails and annular ring shank nails are used because they have a higher withdrawal resistance.
   2) Depth of penetration must also be considered, so 4- to 5-inch (20d to 40d) nails are used to fasten rafters, girders, cleats, or braces to the pressure treated poles. Untreated framing members are fastened to each other with 10d to 12d nails.
   3) Wood splitting is of concern to anyone that has to drive a nail. Dense, heavy woods may have better nail holding capacities, but the heavier woods will also split much easier. The lighter woods are usually compensated by increasing the diameter, length, and number of nails used to secure it. Also, the lighter woods are generally cheaper. If the builder still plans to use the denser wood, predrilling will help to reduce the splitting problem and speed up the driving of the nails; but it also reduces the holding power.
   4) It has been found that using green wood in construction will reduce the holding power of the nails as the wood seasons. The loss of moisture lessens the hold of the nails.
   5) Using nails that are cement coated may double the resistance to withdrawal when driven into softer woods. The resistance drops slightly after about a month.
   6) If the nails are subjected to weathering and the builder wants to prevent corrosion or staining, a zinc nail is recommended.

7) The type of point is important in that a long tapered point will increase holding power but also increase the splitting possibilities. Nails tapered to a blunt point will split wood less than common nails but sacrifice holding capacity.

8) Driving the nails perpendicular to the grain will increase holding power, except in cases of endnailing where the opposite is true.

9) Slant driven nails are usually superior to straight driven nails. The maximum holding strength can be obtained by the use of toe nailed joints using the largest nail possible and driving it into the joint at a 30° angle, burying the shank without mutilating the wood.

10) Clinching the nails increases the resistance strength 170%. Clinch nails across the grain.

11) The minimum nail spacing is: 1 1/2-inch edge distances; 1 inch across the grain; 2 1/2 inch parallel to the grain; and 2 1/4-inch end distance in tension members.

12) Loading limits per nail:

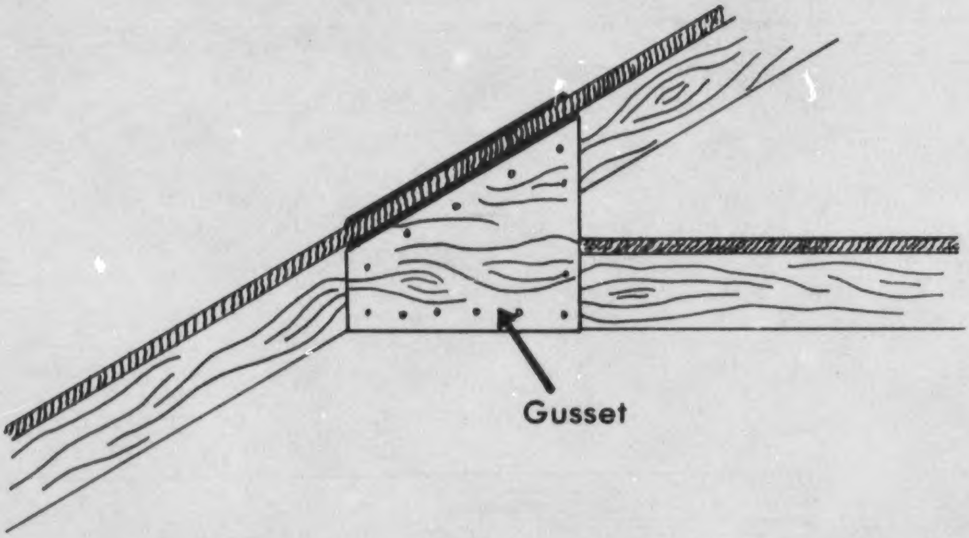
Pennyweight	Length, Inches	Penetration into main member, Inches	Safe Lateral Load, Pounds
Spike			
40d	5	3.4	182
30d	4.5	3.2	165
Common Wire Nail			
40	5	3.0	144
30	4.5	2.7	126
20	4	2.5	113
16	3.5	2.1	88
10 or 12	3-3.25	2.0	77
Threaded, hardened steel Nail (Pole Barn Nail)			
30-60		2.3	113

13) Selecting the right nail is very important, especially under high loads such as in a hay loft. It has been the rule to do more than necessary rather than trying to do just enough to hold something together.

3. The use of adhesives in agricultural buildings has been on the rise because of the strength of new adhesives and the lack of nail holes and other deformed marks.

What are adhesives and what are their uses?

1) There are two primary types of adhesives used in farm building construction. They are casein and resorcinal resin. Each has beneficial properties to contribute to construction.
2) Powdered casein MMM-A-125 Type II is a protein type glue that has a mold inhibitor and is water resistant. It is mixed in equal parts with water, pouring the glue into the water until it is very thick. It must set for 30 minutes before using to allow it to set its properties. Once the glue has "relaxed", it can be spread easily with a paint roller. Other properties include: crack filling, cold application, colorless drying, some wood staining, 70° temperature application, high temperature resistance, and internal usage, because it is not fully waterproof.
3) Resorcinal resin Mol-A-46031 is a waterproof glue that must be used quickly after mixing because of its short "pot" life. It comes in two containers which must be mixed and used within an hour's time. Resin is applied to both surfaces to be joined to assure a strong bond. Other properties include: cold application, dark colored glue line, 70° temperature application, high temperature resistance. Structural gluing is its main usage, partially because it can be used anywhere outdoors.
4) The primary use of glue in construction is in butt joints, like on a truss, with plywood used as a gusset. The gusset sandwiches the bonds to be joined together giving the builder a larger, stronger gluing area.



5) Selecting wood to glue is important to insure a strong bond. Heavy woods are more difficult to glue than light woods, and heartwood is more difficult to glue than sapwood. Select woods with clean, dry surfaces and be sure that they have been planed smooth. If you plan to use woods that have been pressure treated, be sure the preservative is not "bleeding" and the gluing surface has been planed.

6) Never glue wood that has a high moisture content (over 15%). Air dry any wood that is over 15% moisture. Level wood to the part of the building where it will be used.

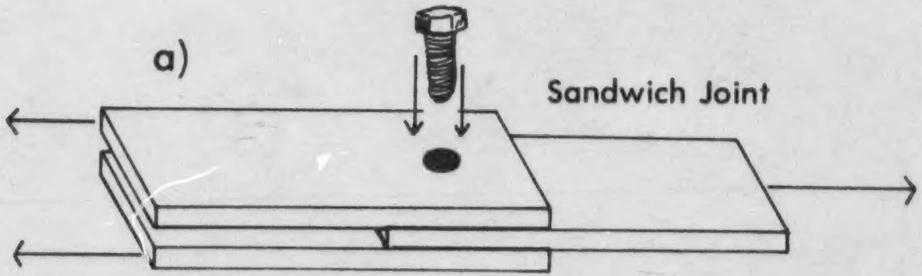
7) When gluing, the process to follow is the manufacturer's directions, keeping the temperature above 70°F to insure quick curing. Follow mixing instructions, keeping the glue free of bubbles and lumps. Before gluing, test for a good fit. Does the glue spread evenly? Apply the glue evenly and completely, and apply pressure with clamps, nails, screws, or other fasteners for 2 to 7 hours.

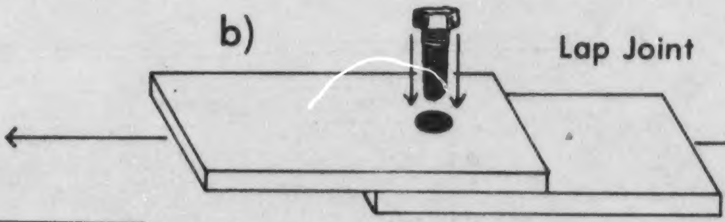
8) When making end to end joints, the larger the surface area glued the better. Bevel the ends to enlarge the surface area.

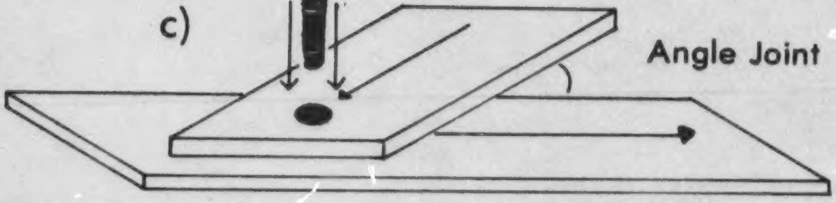
4. Other fasteners that are used to join woods in farm buildings include bolts and split ring connectors.

When are bolts and split ring connectors used and how are they used properly?

1) Bolted joints are used in three situations.
   a) One joint is a sandwich joint with the bolt passing through three wood pieces, the two outside pieces facing one way while the inside piece faces the other way.







   b) A lap joint is a bolted joint with two pieces of wood facing opposite directions. It has half the strength of a sandwich joint.
   c) When the load on an angle bolt in one or more members will be at an angle (90°) to the grain of the wood, the strength of the joint is cut even more. Remember holes must be drilled and washers used.

2) Split ring connectors are used for farm building roof trusses. They are available in two sizes: (1) 2 1/2 inch for 2 inch x 4 inch members and (2) 4 inch used in 2 inch x 6 inch members.

The rings are placed in grooves so that one-half of the ring is let into each member. Joints are lapped, so they must be planned carefully. The joints are of high strength but it is time consuming to drill the grooves, to measure, and to join.

F. Summary

Fasteners can be divided into three groups: nails, glue, and bolt-ring fasteners. Nails are most commonly used because they are fast and easy to use. Glue joints require more wood surface area; but they are strong, especially in truss work. Bolts and rings are best adapted to angled lap joints where strength is needed.

G. Evaluation

1. Set up in the laboratory an identification quiz on the different types of connectors and have the students identify the connectors.
2. Have a gluing exercise to test the holding strength of the resin and casein glues. Stress test two samples with a hydraulic press to see which glue type breaks first. Grade the students on:
   a. Quality of glue bond - 50%
   b. Strength of glue joint -50%

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 5 - How does the builder keep the livestock buildings warm?

Objective: Upon completion of the lesson, students will be able to calculate insulation needs, to determine heat loss, and to calculate supplementary heat needs.

Study Questions:

1. What are the features of an effective livestock building?
2. What are the four functions of insulation?
3. What are the most common types of insulation and the factors to consider when selecting types of insulation?
4. How do you select insulation?
5. What are vapor barriers and their uses?
6. What are the characteristics of heat and moisture?
7. How are buildings affected by temperature-moisture relationships?
8. What are the insulation values for common building materials?

Reference:

1. Keeping Livestock Buildings Warm, AED-13, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 50¢

42

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 5 - How does the builder keep the livestock building warm?

TEACHING PROCEDURE

A. Review

B. Motivation: Demonstrate the three types of heat loss: (1) conduction--heat a metal bar at one end and melt wax on the other end; (2) convection--set up a blower on a heating element and force hot air away from the element, and (3) radiation--heat an element and feel the air around it for heat given off. These are the three ways to lose heat from a house or building.

C. Assignment: Have the students check their homes or buildings for the type of insulation installed.

D. Supervised Study

E. Discussion

1. Have students brainstorm ideas for controlling heat loss and list them on the board.

   What are the features of an effective livestock building?

   1) Tight construction
   2) Insulation
   3) Vapor barriers
   4) Insulated doors and windows
   5) Ventilation systems

2. Insulation is any material that reduces the rate at which heat is transferred from one area to another. Write this definition on the board.

   What are the four functions of insulation?

   1) Conserve heat in cold weather
   2) Reduce rate of heat gain in hot weather
   3) Control surface condensation
   4) Reduce rate of heat loss by good foundation insulation

3. Insulation is usually bulky, porous, lightweight material with countless air spaces. Discuss selecting types of insulation for a structure.

What are the most common types of insulation and the factors to consider when selecting types of insulation?

1) Factors for selection
   a) How is it to be used?
   b) How adaptable is it?
   c) What is the relative cost?
   d) Does it install easily?
2) Loose-fill insulation, mineral wool, cork
3) Insulation butts and blankets
4) Insulation board
5) Block or ridge insulation
6) Air space
7) Reflective insulation
8) Additives to concrete

4. All building materials have some insulating capacity. Compare the various materials in class and rank.

How do you select insulation?

1) "R" or insulation value
2) "K", "C", "U" values
3) Look at Figure 6 on page 3 of reference.

5. Moisture is a severe problem in most farm structures and must be taken into account to prevent a breakdown in the insulation.

What are vapor barriers and their uses?

1) When it is warm inside and cold outside, vapor condenses when it travels toward the cold.
2) Place the barrier near the warm side of the wall.
3) Common types of vapor barriers are aluminum foil, 4 mil plastic film, and asphalt-impregnated building papers.
4) Use tables to select the right type of vapor barrier. (See Table VI in your reference.) The smaller numbers are better.
5) Refer to drawing on page 4 of your reference for practical uses of vapor barriers.

6. This section will help to clarify questions about heat transfer and moisture behavior.

What are the characteristics of heat and moisture?

1) Heat is a transferable form of energy.
2) Temperature is a magnitude of heat (btu).
3) Latent heat is a change of state without a temperature change.
4) Sensible heat is a change in temperature.
5) Total heat is equal to steps 3 plus 4.

7. Animals release both latent and sensible heat, causing high levels of moisture in the air.

How are the buildings affected by temperature-moisture relationships?

1) T-M relationships help determine ventilation needs.
2) Cooling air reduces moisture-holding capacity.
3) Sensible heat gain equals sensible heat loss if the temperature is to remain constant.
4) Calculate heat gain.
5) Learn the procedure for balancing temperature.

8. After the basic plans have been made for construction, set a "R" value to reach and calculate needed additional insulation.

What are the insulation values for common building materials?

1) Use Table I in the Appendix on page 10 of your reference for "R" values.
2) Tables II and III show frame construction "R" values.
3) Table IV shows "R" values of concrete wall construction.
4) Table V gives "R" values for roof, ceiling, doors, and floor perimeter.

F. Summary

Insulating farm buildings will save money. Several types of insulation are available, so select carefully for the job. A vapor barrier is essential for confinement operations to extend the life of buildings.

G. Evaluation

Answers to Exam

1. Any four of the following:
    a. Tight construction
    b. Insulation
    c. Vapor barriers
    d. Insulated doors and windows
    e. Ventilation systems
2. F
3. F
4. F
5. T
6. T

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 5 - How does the builder keep the livestock building warm?

EXAM

1. List four features of an effective livestock building?

   a.

   b.

   c.

   d.

T F 2. A function of insulation is to conserve heat in the summer.

T F 3. Foundation insulation is only needed in northern states.

T F 4. Insulation is selected solely on its "R" value.

T F 5. Water condenses when the cold air outside meets the warm air inside.

T F 6. Latent heat is the changing of water to vapor in the lungs.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 6 - How is the foundation of a farm building laid out and the footings set?

Objective: Upon completion of the lesson, students will be able to lay out the foundation for a building and dig and set the footings for the building.

Study Questions:

1. How is a foundation plot laid out with a builder's level?
2. What is the function of batter boards in building construction?
3. How are footings set in farm buildings?
4. How are the poles set in the ground for a pole structure?
5. What is the use of pin and post construction?
6. What type of foundation is needed for a light-wood-frame (stud) construction?

References:

1. Practical Farm Buildings, available through The Interstate Printers and Publishers, Inc., Danville, IL 61832 $7.95
2. Utility Buildings, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
3. Structures and Environment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $5.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 6 - How is the foundation of a farm building laid out and the footings set?

TEACHING PROCEDURE

A. Review basic surveying.

B. Motivation: Demonstrate the use of the level and have a contest as to which team can make the squarest foundation 25 feet x 25 feet.

C. Assignment

D. Supervised Study: Check the squareness of the school building.

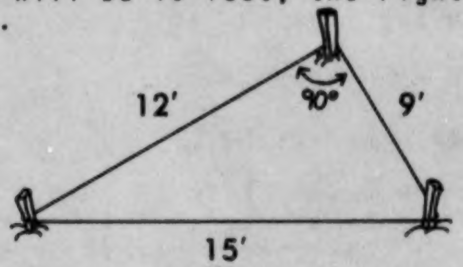
E. Discussion

1. The type of foundation to be laid out depends on the type of farm structure to be constructed.

   How is a foundation plot laid out with a builder's level and stakes?

   1) After the building site has been cleared of all debris and stumps and leveled to the proper slope, the layout of the building lines can begin.
   2) Usually the corners of the building are set by a surveyor according to the building codes of the area. Be sure to check the codes before building, or expensive problems can arise if the building has to be moved.
   3) When the location has been determined, building lines are laid out to indicate the outside lines of the foundation wall. Set corner stakes with nails at the top to mark the corners of the structure. Lay them out with transits and levels to be sure the stakes are square and properly set. To lay out the corners with a transit or level, set the device at one corner and sight in one other corner along which the wall will run; set the horizontal circle index to zero and swing it 90° toward the next corner to check the squareness. Move the transit to another corner and repeat the process. What will result are square corners. Be sure to measure the distances between the stakes; the level will be measuring squareness not distance.

4) Another way to check squareness is with the 3-4-5 method. From the corner stake, measure 9 feet on one line and 12 feet on the other line; and if the corner is square, the distance from the 9 foot and 12 foot points will be 15 feet, the right angle theory.

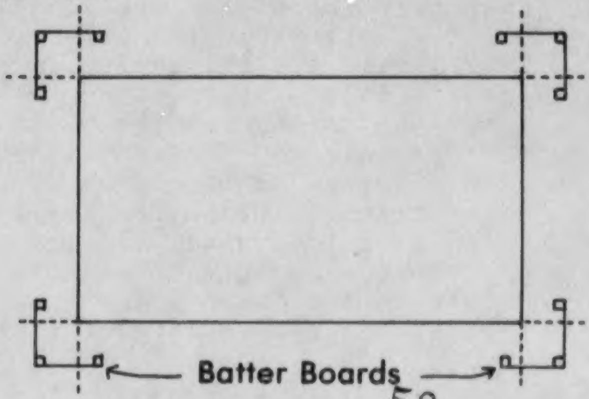


5) After all the corners are set and if the building is square, the diagonals will be equal.

2. After setting the stakes, the work has just begun before the footings can be laid. The batter boards aid in this process.

What is the function of batter boards in building construction?

1) Batter boards are located at each corner and three to four feet away from the excavation line. The batters are made with 2-inch by 2-inch stakes and 1-foot by 6-foot lumber. In a simple rectangular layout, four batters will be needed, one at each corner.
2) Lines are stretched across opposite batter boards and then adjusted so that they align with the centers of the corner stakes. This can be done by using a plumb bob for exact placement of the lines over the marks. The lines should then be marked on the batter boards with a small kerf cut and weighted to keep the line taut. These lines will give a line to follow when excavating without the problem of the lines being dug up because they are beyond the foundation boundaries.



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3. Just like the saying "behind every good man there's a woman", "behind every good building there's a foundation." Without a good foundation, the building could lead a very short life.

   How are footings set in farm buildings?

   1) When the lines along which the building is to be built are established, a trench is dug for the foundation footing. The depth of the footing is dependent on the use of the building and the location in the country. In Missouri the recommendations are:
      a) Light buildings: 12 inches to 18 inches
      b) Farm house: 18 inches to 24 inches
      c) Heavy permanent barns and storage: 24 inches to 30 inches
   2) A rule of thumb for the width of the footing for light buildings is "the footing is twice as wide, and as thick, as the foundation wall is wide."
   3) In locations that are subjected to periodic flooding, a drain should be placed near the footing to prevent water build-up that could possibly collapse a wall.
   4) After the hole has been dug for the footings, it must be determined if the soil is rigid enough to allow direct pouring or if a form is needed. Be sure to level the surface of the forms and the base of the foundation.
   5) Premix concrete is the best for casting footings. Check the depth during pouring; be sure to order enough concrete; and smooth the surface of the footings to allow for good block contact.
   6) An option available is to scribe a 2-inch by 4-inch key in the footing down the center to add strength to the foundation by locking the blocks and mortar to the foundation.

4. A large number of the small and moderate size farm structures are constructed using poles as the basic foundation.

   How are the poles set in the ground for a pole structure?

1) Pole-type construction utilizes preservative-treated poles set into the ground as main structural members. The poles serve two purposes: vertical support for the building and fixity at the bottom against rotation to provide lateral bracing. These foundations must resist settling, soil movement caused by freezing and thawing, and the uplift and over-turning force of wind on the above ground structure.
2) After spacing of the poles has been determined, the locations should be marked on the foundation line establshed earlier. This is accomplished by setting up the transit facing down the line along which the poles will be placed and using the tape measure. Mark the center of each hole with a stake. Align the stakes with the transit. The transit can also be used to align the hole digger and check squareness and alignment of each pole as it is put in place.
3) Depth of embedment of the poles will depend on the length of the pole. Approximately one-fourth of the pole should be buried in the ground. The length of the pole needed can be calculated as follows: Total length equals ceiling height plus 1 foot to connect truss plus embedment.
4) The diameter of the pole needed will also vary. The determining factors will be the eave height, load, and pole spacings. Examples would be 4-inch diameter poles for 8-foot eaves and 8-foot pole spacing; 5-inch poles for 8-foot eaves and 12-foot or 16-foot pole spacings; 5-inch poles for 10-foot eaves and 8-foot or 12-foot pole spacings; 6-inch poles for 12-foot eaves and 8-foot or 12-foot pole spacings; and 7-inch poles for 14-foot eaves and 12-foot or 16-foot pole spacings. A table is available in the Structures and Environment Handbook.
5) Stabilizing or setting the pole in the ground can be accomplished by several acceptable methods.
    a) The simplest method is the tamped soil method. This method involves drilling to the recommended depth, setting the pole by string or transit, and replacing the soil around the pole, packing it tightly with a steel rod or other packing means. Under high loads, it tends to settle, pull out, or shift easily.
    b) The first concrete method involves drilling the hole as before but slightly deeper (6 inches to 10 inches) than with tampered earth to allow for a concrete base or pad. The pole is set in the concrete at the

bottom of the hole so it penetrates the concrete about 6 inches. Then allow it to harden. Fill the remainder of the hole with earth and tamp tightly.

c) The concrete collar method involves setting the pole and tamping earth around the pole leaving about 10 inches at the top of the hole. Pour concrete for the last 10 inches to form a collar.

d) The method found to be best is a complete concrete encasement of the pole the full depth of the hole. It was found through testing to have the best resistance to withdrawal, settling, and deflection.

6) To improve the holding power of the poles, insert bolts or lag screws to stop uplift and settlement before setting the poles in the ground.

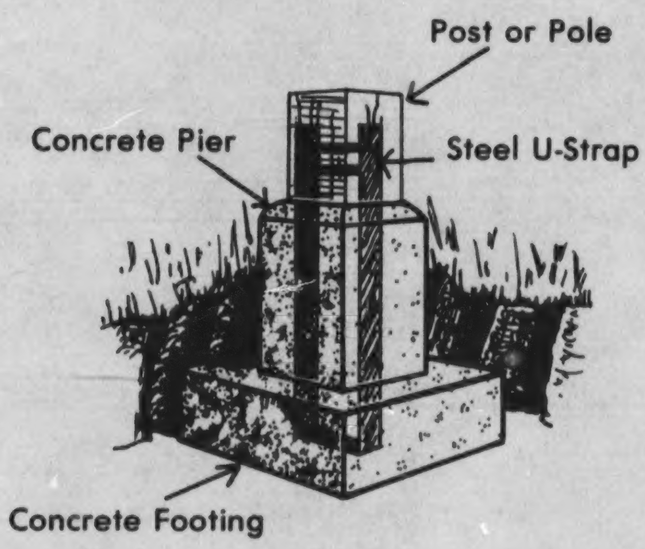
7) Other poles not mentioned earlier but which are in use include slab, sawed and steel posts.

8) If high stress is expected, be sure to use reinforcing steel in the concrete encasements.

5. In shallow soils or hardpan soils, it may not be possible to dig a hole three or four feet deep. Methods are in use that helps to solve these problems.

What is the use of pier and post construction?

1) Columns and posts should have square-shaped footings with a pier. The pier and footing are cast as one, with a steel u-strap cast as a part of the unit.



2) The footing may be 24 inches by 24 inches by 12 inches or 30 inches by 30 inches by 12 inches. The pier should be 3 inches above the ground. So the depth to dig would be about 16 inches to 20 inches.

3) The posts are attached to the piers by bolts which pass through holes drilled through the lower end of the post.

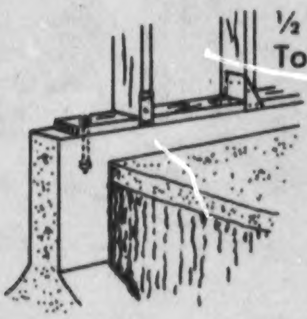
4) Strength will not be as high as if they had been set in the ground.

6. For constructing buildings that are to be scaled and walled, a different type of foundation is needed than the afore mentioned ones.

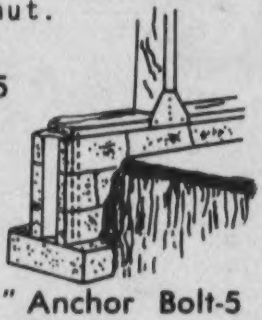
What type of foundation is needed for light-wood-frame (stud) construction?

1) If you plan to use light-wood-frame construction, you will be using a continuous-poured concrete or concrete-block foundation. This foundation will be carrying the weight of the building, so it must be constructed on solid ground and set below the frost line to avoid heaving. (This was discussed earlier so the depths and footing sizes will not be repeated.)

2) To hold the wall frames upright and tight to the foundation, some preplanning is necessary. Before pouring the footing, purchase or make enough anchor bolts to have one for each five to six feet of foundation. Pour the footing and place these 1/2-inch anchor bolts in the wet concrete. The bolts will be used later to hold the bottom board of the wall frame. If 3 courses of block are to be laid on the footing before the wall frame is attached, be sure the anchor bolt is long enough to stretch from 2 inches into the footing, through the three courses of block, and through the piece of wood. Two inches + 8 inches + 8 inches + 8 inches + 2 inches equals 28 inches long plus 2 inches for the washers and nut.



½" Anchor Bolt-5 To 6 Ft. Apart



½" Anchor Bolt-5 To 6 Ft. Apart

F. Summary

The foundation is the base on which the rest of the farm building is set. The different types include poles, footings, footings and block, footings and piers, and other combinations of items. First the foundation must be carefully planned; then it should be laid out carefully and accurately. Then and only then can the setting of the foundation take place.

G. Evaluation

1. Set the stakes for a 40-foot x 50-foot farm structure using a builder's level.
2. Dig a footing for a farm structure using poles, poured concrete, and pier methods.
3. Pour the above, using lime and sand mixes.
4. Set poles; then align for straightness at all angles.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 7 - How is the floor framed in a farm structure?

Objective: Upon the completion of the lesson, students will be able to construct a floor on a foundation and to install subflooring.

Study Questions:

1. What are the terms associated with floor framing?
2. What are the framing styles and members used?
3. How are the joists set in place?
4. How is the subflooring installed?

References:

1. *Practical Farm Buildings*, available through The Interstate Printers and Publishers, Inc., Danville, IL 61832 $7.95
2. *Basic Carpentry*, available through Reston Publishing Company, Inc., Reston, VA 22090 $15.95
3. *Residential Carpentry*, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $6.50
4. Transparencies:
   a. TM-1: Types of Framing
   b. TM-2: Floor Members
   c. TM-3: Joists Used in Platform and Balloon Framing
   d. TM-4: Lap Joists
   e. TM-5: Beam Ledger and Framing Anchor Joists

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 7 - How is the floor framed in a farm structure?

TEACHING PROCEDURE

A. Review fasteners and foundations, especially anchoring bolts.

B. Motivation: Show a cross-section of a floor with all its parts and ask if any of the students have seen the underside of a house with the cross members.

C. Assignment: Diagram the floor of the student's home by looking under the house, Look for x-pieces, supports, anchors, etc.

D. Supervised Study: As a class analyze the subfloor of the school.

E. Discussion

   1. The terms associated with flooring are necessary for complete understanding.

      What are the terms associated with floor framing?

      1) Balloon framing is a type of building construction in which the studs extend in one piece from the foundation to the roof.
      2) Beam or girder is any large piece of timber, stone, iron, or other material used to support concentrated loads at particular points along its length.
      3) Bearing is the part of a building member resting on its supports.
      4) Bridging is solid lumber or small wooden or steel pieces fitted in pairs from the bottom of one joist to the top of the adjacent joist and crossed to stiffen and help distribute the load.
      5) Crawl space is the space between the first floor and ground in houses without basements.
      6) Crown relates to the high side of the crook in framing lumber.
      7) Foundation is the supporting portion of a structure below the first floor construction, including the footings.

8) Girder is a large supporting beam used to support concentrated loads along its length.
9) Header is a horizontal load-bearing support over an opening such as a door or window; also it is a supporting member placed at the head and foot of an opening.
10) Headroom is the vertical height in a doorway and the clear height between tread and ceiling in a stairway.
11) Joist header is the framing member into which the common joists are fitted, forming the box sill, or a member used to support the free end of joists over openings such as stairs, chimneys, and other openings.
12) Joist is one of a series of parallel framing members used to support floor and ceiling loads and supported in turn by beams or girders.
13) Joist hanger is a metal bracket used to support joists.
14) Lally column is a metal column or post used to support beams and girders, usually filled with concrete.
15) Overhang is a projection beyond a wall.
16) Pier is a masonry pillar used for supporting structural members.
17) Sealer strip is the layer of material, usually fiberglass, placed between the sill and top of the foundation wall; it keeps out drafts and insects.
18) Sill is the lowest member of the frame of a structure resting horizontally on the foundation and supporting the uprights of the frame.
19) Sill sealer is a resilient waterproof material used under the sills as a seal against air, dirt, and insects.
20) Stressed skin is a panel consisting of two wood faces glued to a framework.
21) Subfloor is a board or panel laid directly on the floor joists over which a finished floor will be laid.
22) Termite shield is a shield, usually made of sheet metal, placed on a foundation wall or around pipes to prevent the passage of termites into the structure.
23) Trimmer is a beam or joist into which a header is framed.
24) Underlayment is the material on which a finished floor is placed.
25) Western framing is a system of framing a building where the floor joists of each story rest on the top plates of the story below, and the bearing walls and partitions rest on the subfloor of each story.

2. The parts of the framing system are also very important to framing a floor.

What are the framing styles and members used?

1) There are two main styles of framing the floor, and they are the western and balloon methods. TM-1 shows the differences between the two methods. In western framing, a platform is built on which the wall members are attached. With balloon framing, the wall sections connect to the foundation and the studs reach to the roof line.
2) There are eight primary members in the floor framing system. They are (TM-2):
    a) Sill sealer
        (1) The sill sealer provides a seal against air, dirt, and insects when it is placed between the sill and the foundation wall.
    b) Termite shield
        (1) The termite shield is applied between the sill and around pipes to prevent the passage of termites into the structure. It is flashing of metal bent downward, because termites cannot bend their bodies in the middle and therefore cannot come over the edge of the metal.
    c) Sill
        (1) The sill is the wood part of the floor that is attached to the foundation. It is attached to the foundation wall by either a sill anchor, which is a bolt embedded in the foundation wall that projects through the sill and provides an anchor for the sill, or by using a concrete nail, which consists of a hardened steel nail which is driven or shot through the sill into the foundation.
    d) Joists and Joist header
        (1) The joists and joist headers carry and
        (2) spread the weight of the building to the foundation. They are usually made of 2- to 3-inch lumber placed on the edge to which the subflooring is nailed. They generally will run the short way across the building with spacings of 16 inches on center. Be sure to select joists that will handle the load with a minimum of sag to prevent damage to the rest of the structure and to prevent endangering lives.

e) Beam or girder

(1) The beams or girders support concentrated loads at particular points along their lengths. They are generally made from large pieces of timber, stone, iron, or other material used to span an open area upon which the floor joists rest.

f) Bridging

(1) Bridging helps stiffen and distribute the loads incurred by the joists, sill, and beams. When made from solid lumber, bridging is generally the same size stock and is staggered between the joists at 90° angles to promote more strength. Another method used is lumber or metal "X" bridging, which are usually made from one- by four-inch lumber and fitted in pairs from the bottom of one joist to the top of the adjacent joist and crossed.

g) Subflooring

(1) The subflooring is plywood sheathing which covers joists, making a solid surface upon which hardwood floors, tile, or carpeting can be laid during the final finishing of the structure.

3) To determine the amount of wood needed to complete the flooring, it must be calculated by member type.

a) Sill board feet should measure 2 inches by 4 inches or 2 inches by 6 inches with enough length to cover all the foundation surfaces.

b) Beams or girders are determined by the specifications of the building and should be installed where the expected load will be high. Beams are usually metal or wood. The metal beams are usually I-beams supported by pipe columns called lallies and supported on the ends by the foundation. Wood beams are made by nailing 2 or more pieces of 2-inch lumber together. If two pieces are used, nail them together with ten penny nails spaced 16 inches apart and staggered.

c) If 3 or more pieces are used, nail from both sides with twenty penny nails spaced 30 inches apart and staggered. Also stagger the sandwiched board with the outer boards. The beam should rest in a notch in the foundation formed by leaving out a block or making one when pouring the foundation wall. The beam should have a minimum 4-inch bearing on the foundation and be flush with the top of the foundation wall.

d) To determine the board feet of joists needed, determine the length needed from the foundation plan and round up to the nearest even foot. Secondly, determine the number of joists needed.
   (1) For 16-inch centers, multiply the length of the building by 3/4 and add one joist for the end and add one joist for each partition that runs parallel to the joists.
   (2) For 24-inch centers, multiply the length of the building by 1/2 and add one joist for the end.

e) To determine the need for joist headers, allow for twice the length of the building and all openings.

f) Bridging usually consists of one- by four-inch rough lumber and is required in spans over eight feet in length and less than sixteen feet in length. Two rows of bridging are required in spans over sixteen feet. For X-bridging first find the number or rows of bridging needed; secondly, determine the length of each row of bridging. Then multiply the sum of all row lengths by the factor below to get linear feet of bridging.

Joist Size	Spacing	Linear Feet of Material Per Foot of Bridging Row
2" x 6" to 2" x 10"	16'	2
2" x 12"	16'	2 1/4
2" x 14"	16'	2 1/2

To calculate steel bridging, first determine the number of rows of bridging needed and the length of each row. Multiply the total linear footage of bridging rows by 3/4 to find the number of spaces between joists 16 inches on center. Then multiply the above total by two to determine the number of pieces required.

g) Sill sealer is calculated in total linear feet of foundation, and termite shield is the same length and usually consists of 26 gauge galvanized sheet metal 12 inches wide.

3. When building the floor, careful consideration must be taken when placing the joists.

How are joists set in place?

1) In platform or western framing, the joists are set on the sill and a board called the band is placed on the outside end of the joists perpendicular to them. See TM-3. This means that careful measurements to allow for the extra board are needed.
2) In balloon framing, the joists ends are placed flush with the outside wall and the wall studs are placed perpendicular to them. See TM-3.
3) If the joists are to overlap on a center girder or beam, the last placement of joists will have different on center measurements. For 16-inch OC spacing, the first joist is 16 inches but the opposite joist is 14 1/2 inches--to allow for the overlap error. Then each board is placed at 16-inch centers. The joists are toe nailed to the sill with two 10d nails and then nailed through a header joist (if platform framing) with three 16 penny nails. See TM-4.
4) To fasten the joists to beams, three methods prevail for wood beams. One is the ledger system where the joist rests on a small ledge on the beam and is toe nailed. Another method is to use framing anchors, which are right-angled metal plates nailed to both the girder and joist. The third method is the overlap where the joists overlap on top of the beam and are nailed together and toe nailed to the beam. See TM-5.

4. After the floor has been formed and attached securely to the foundation, subflooring can be installed.

How is the subflooring installed?

1) The subfloor is placed directly over the joists and serves as a base surface for the finished floor. Generally C-D interior grade plywood is used for subflooring. The panels are usually marked 32/16, the 32 for roofing centers and the 16 for 16-inch centers on floors.
2) When installing plywood with the best side up and the boards lying with the long dimension across the joists, leave a 1/16-inch space at the ends and 1/8 inch at the sides to allow for moisture expansion. Use a commercial spacer to insure quicker completion. Be sure to stagger the boards with the first row starting with a 4-foot by 8-foot board. Then beside it put a 4-foot by 4-foot board. Then place a 4-foot by 8-foot board until floor is completed. Use six or eight penny nails to secure the plywood with the nails spaced 6 inches apart around the perimeter and 10 inches apart along the intermediate members. You can mark the girders under the plywood with a chalkline on top of the boards to speed up nailing.
3) Glued floors have an advantage in their quietness and anti-warping characteristics. If the proper adhesive is used and the glue is applied correctly, the floor will last longer and be stronger than nailed floors.

F. Summary

Setting a floor on a foundation is not an easy task to complete. Careful and good planning will result in the quality, strong floor that is needed in a farm structure. Too little support for the floor will lead to extensive repairs in the future.

G. Evaluation

Answers to Exam

Matching:

1. b
2. d
3. h
4. f
5. c
6. e
7. a
8. g
9. j
10. l
11. k
12. i

Identification:

13. Sill sealer
14. Termite shield
15. Sill
16. Joists
17. Joist headers
18. Beam or girder
19. Bridging
20. Subfloor

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 7 - How is the floor framed in a farm structure?

EXAM

Match the following list of terms to the correct definition.

_____ 1. Beam or girder

_____ 2. Bridging

_____ 3. Crown

_____ 4. Foundation

_____ 5. Joist header

_____ 6. Joist

_____ 7. Balloon framing

_____ 8. Termite shield

_____ 9. Sill

_____ 10. Sill sealer

_____ 11. Subfloor

_____ 12. Western framing

a. A type of building construction in which the studs extend in one piece from the foundation to the roof

b. Any large piece of timber, stone, iron, or other material used to support concentrated loads at particular points along its length.

c. The framing member into which the common joists are fitted forming the box sill or a member used to support the free end of joists over openings such as stairs, chimneys, and other openings.

d. Solid lumber or small wooden or steel pieces fitted in pairs from the bottom of one joist to the top of the adjacent joist and crossed to stiffen and help distribute the load.

e. One of a series of parallel framing members used to support floor and ceiling loads and supported in turn by beams or girders.

f. The supporting portion of a structure below the first floor construction including the footings

g. A shield, usually made of sheet metal, placed on a foundation wall or around pipes to prevent the passage of termites into the structure.

h. Relating to the high side of the crook in framing lumber

i. A system of framing a building where the floor joists of each story rest on the top plates of the story below, and the bearing walls and partitions rest on the subfloor of each story

j. The lowest member of the frame of a structure resting horizontally on the foundation and supporting the uprights of the frame

k. Boards or panels laid directly on the floor joists over which a finished floor will be laid.

l. A resilient waterproof material used under the sills as a seal against air, dirt, and insects.

Identify eight framing members that make up the floor and sill.

13.

14.

15.

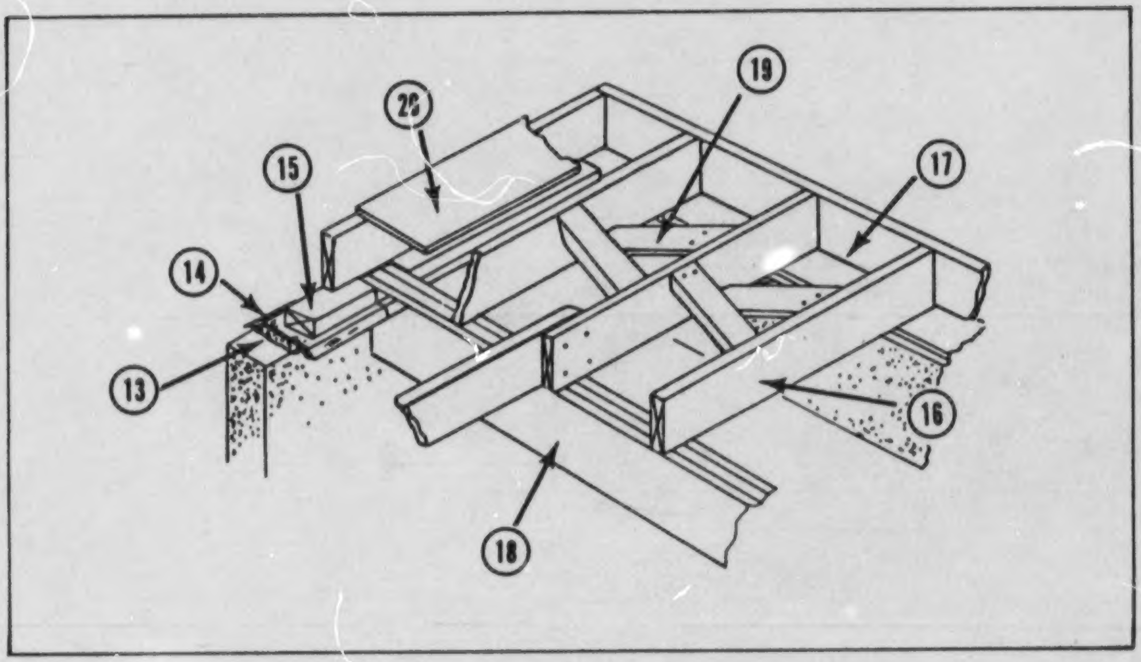
16.

17.

18.

19.

20.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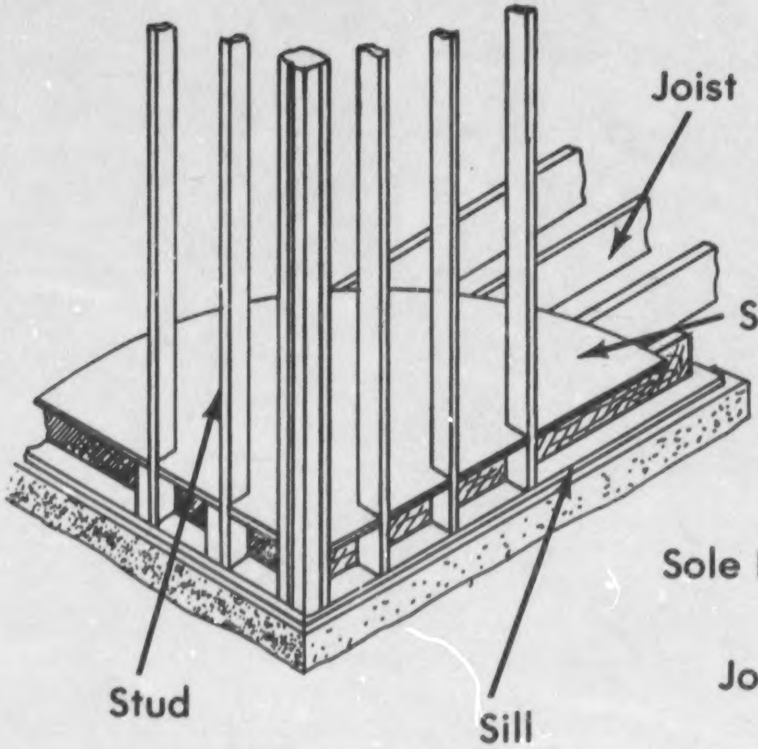
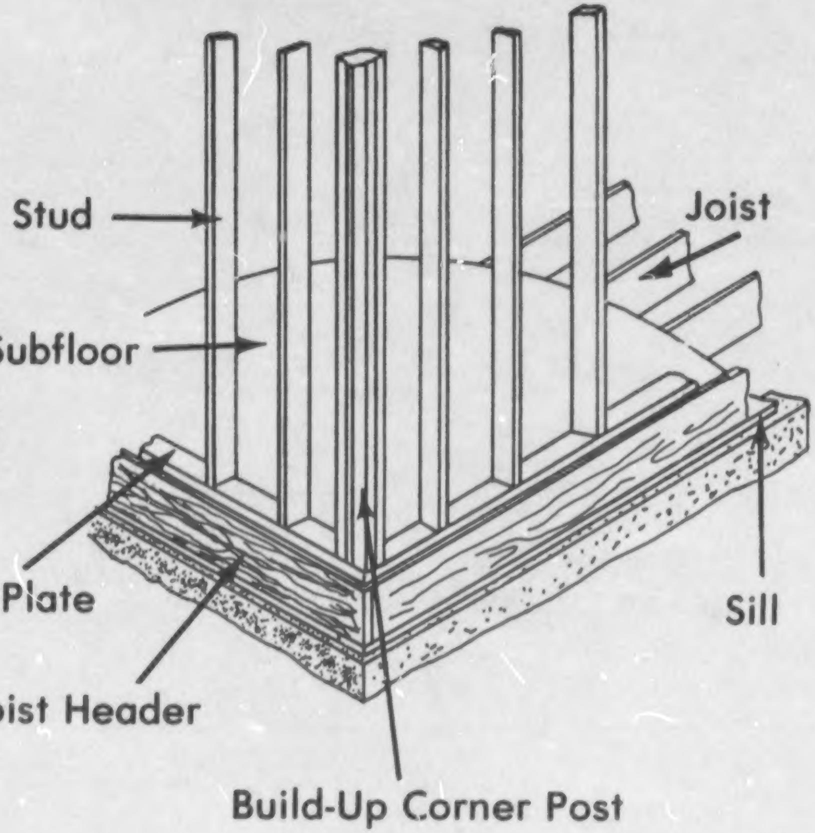
Types of Framing

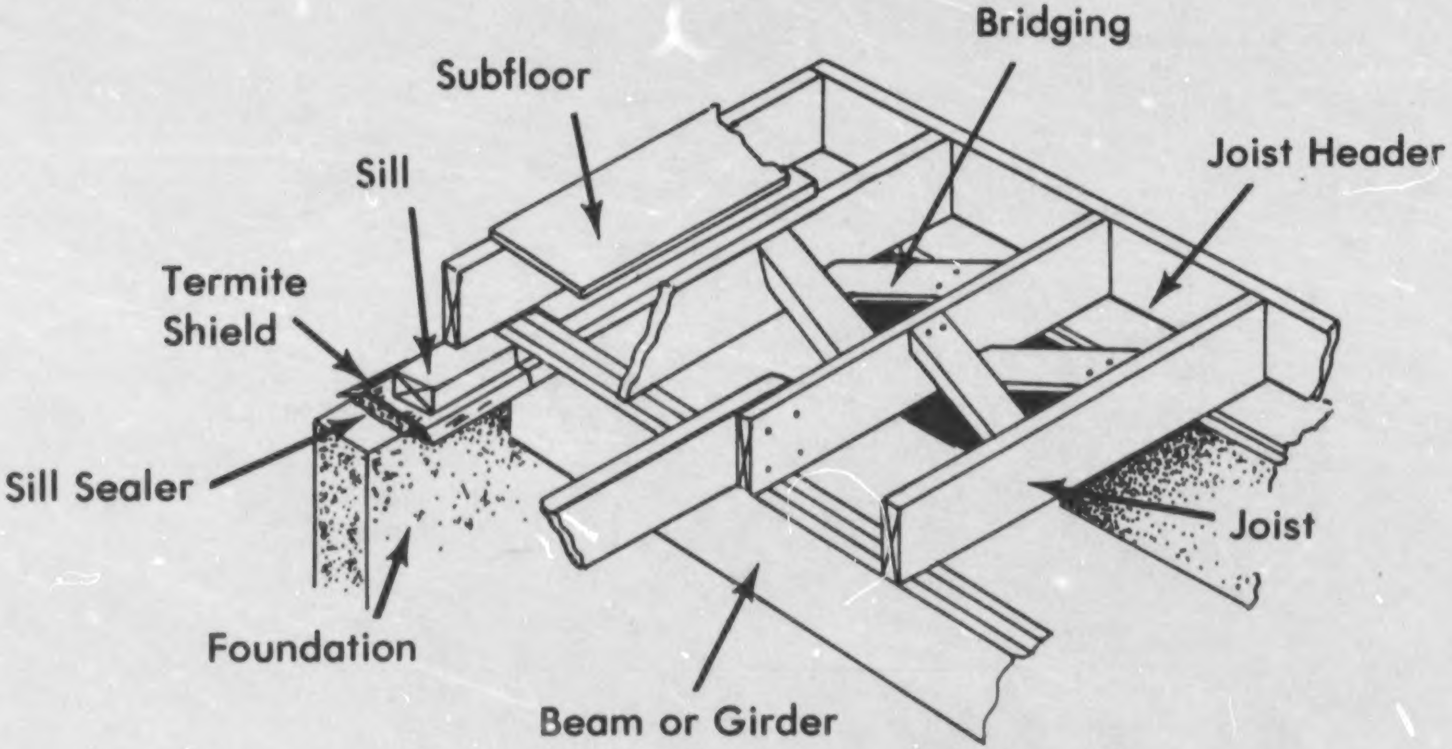
Balloon Framing


Joist
Subfloor
Stud
Sill

Western Framing


Stud
Joist
Subfloor
Sole Plate
Joist Header
Sill
Build-Up Corner Post

Floor Members


Bridging
Subfloor
Joist Header
Sill
Termite Shield
Sill Sealer
Joist
Foundation
Beam or Girder

Joists Used in Platform and Balloon Framing

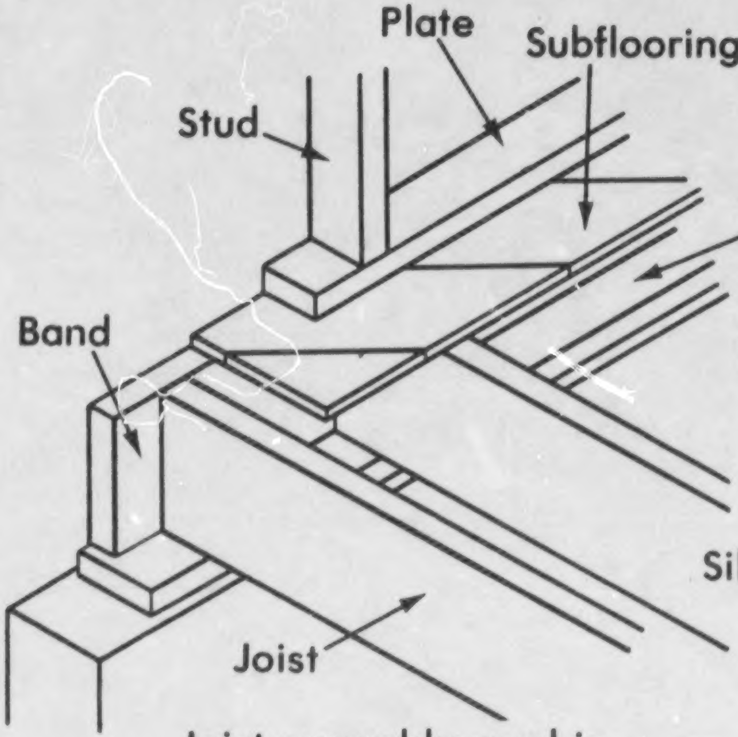
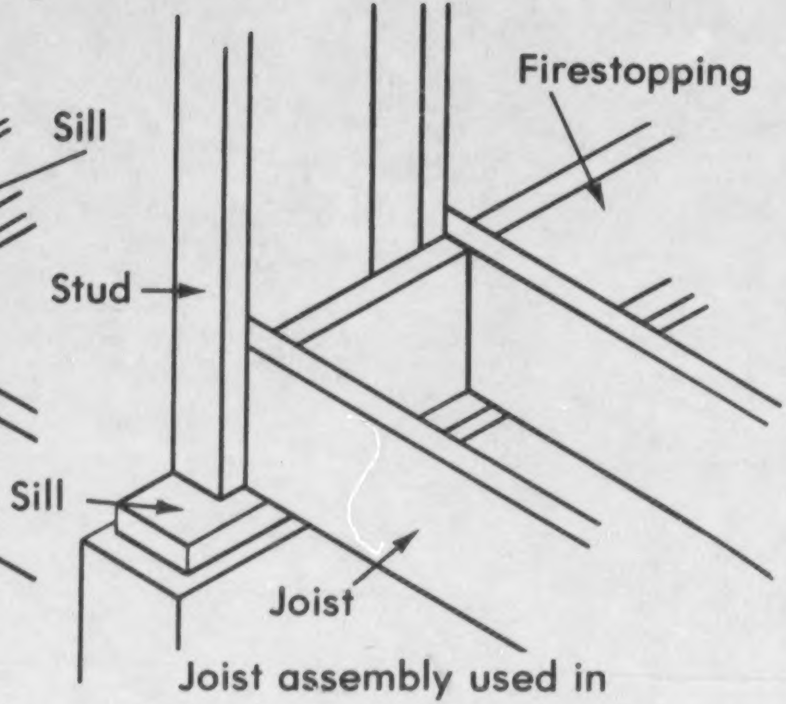


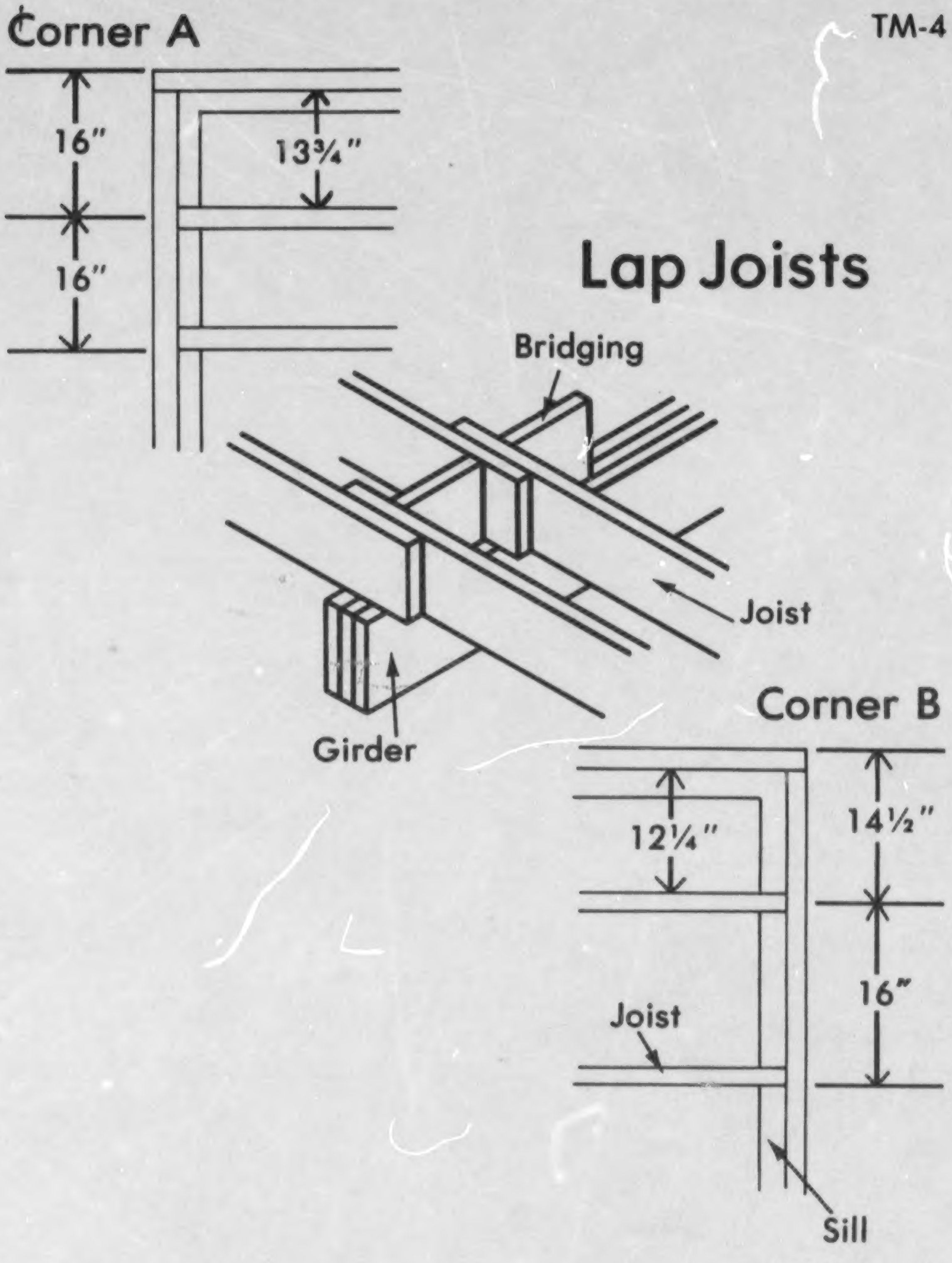
Plate
Subflooring
Stud
Sill
Band
Joist

Joist assembly used in platform framing.


Firestopping
Stud
Sill
Joist

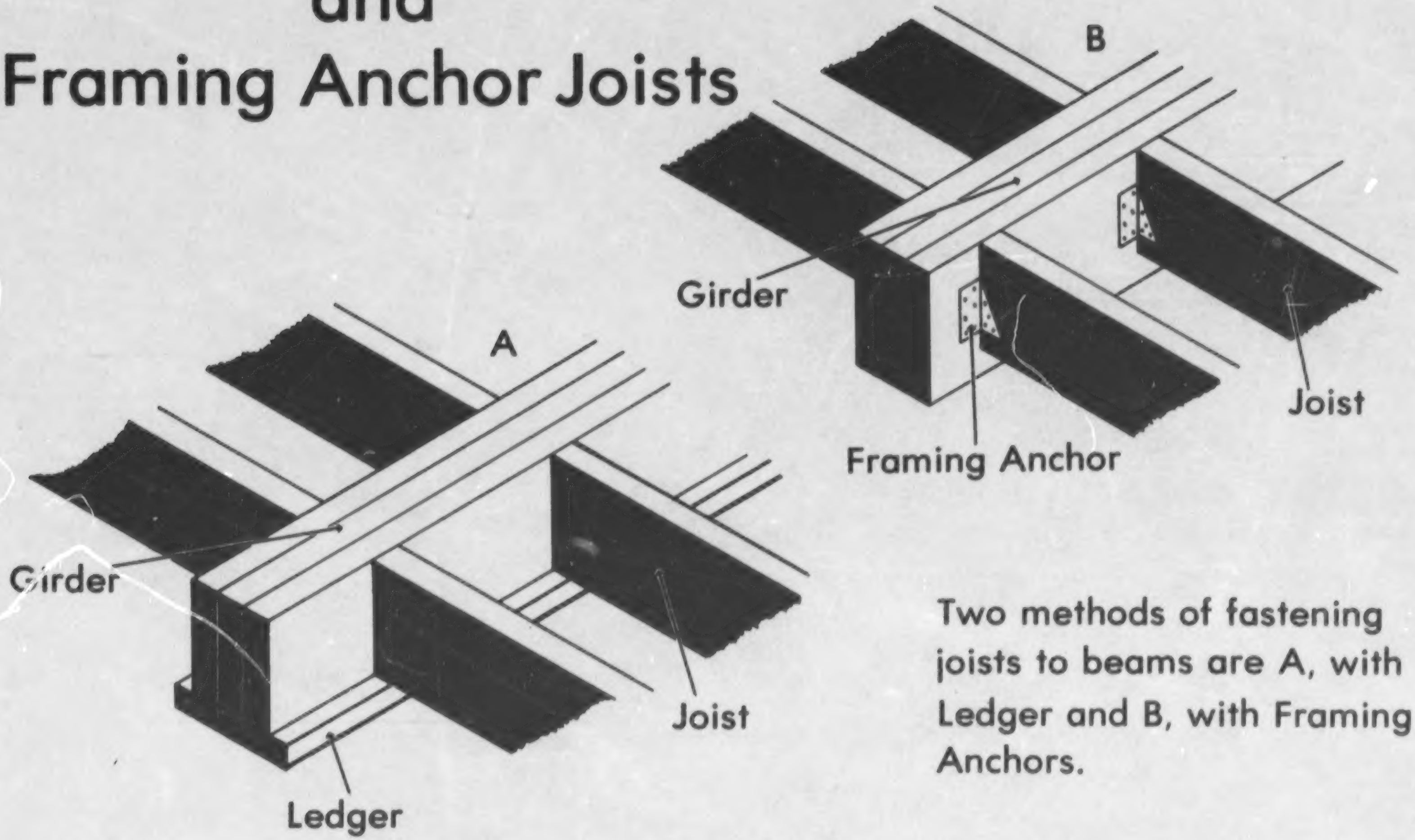
Joist assembly used in balloon framing.

Lap Joists


Corner A
16"
13¾"
16"
Bridging
Joist
Girder
Corner B
12¼"
14½"
16"
Joist
Sill

Spacing of joists differs at corners A and B when joists are lapped.

Beam Ledger and Framing Anchor Joists


B
Girder
Framing Anchor
Joist
A
Girder
Ledger
Joist

Two methods of fastening joists to beams are A, with Ledger and B, with Framing Anchors.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 8 - How are walls for farm buildings constructed?

Objective: Upon the conclusion of the lesson, students will be able to list the purposes of walls, the types of walls, the types of wall supports, and the types of siding used in farm structures.

Study Questions:

1. What are the three purposes of walls?
2. What are the components of a frame wall?
3. What is light-wood-frame construction?
4. What types of siding are used in farm structures?

References:

1. Utility Buildings, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Practical Farm Buildings, available from The Interstate Printers and Publishers, Inc., Danville, IL 61832 $7.95

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 8 - How are walls for farm buildings constructed?

TEACHING PROCEDURE

A. Review foundations and wood protection.

B. Motivation: What types of walls are in home and farm structures? How are they alike and how are they different? Where does the strength lie in a wall? Do all walls support the roof? Are all walls framed?

C. Assignment

D. Supervised Study: Go through examples of structures with load-bearing walls and non-load-bearing walls, pole structures, and frame structures.

E. Discussion

1. Walls serve many purposes to the building. List these purposes on the board.

   What are the three purposes of walls?

   1) One purpose is to support vertical load caused by by snow or rain on a roof.
   2) Another purpose is to resist lateral loads caused by material piled against the wall.
   3) The third purpose of walls it to keep out rain, snow, and wind.

2. To give a wall strength to resist the loads put upon it, certain stresses and strains must be considered in the design. What are these factors?

   What are the components of a frame wall?

   1) There are a network of members to support the load on a frame wall.
   2) Outside surface of a frame wall is to keep out rain, snow, and wind.
   3) Inside surface of a frame wall is to contain materials or animals in the building.
   4) Cut-in braces and let-in braces angled up to the corners of the wall increase the rigidity of the wall.
   5) Anchoring to masonry footing is an important part of a frame wall.

3. The light-wood-frame construction method involves building a foundation with anchoring bolts in the foundation wall to hold the wall frames in place. Is this method common to your area?

   What is light-wood-frame construction?

   1) Light-wood-frame construction is anchoring with 1/2-inch bolts set at least 6 inches deep in the foundation 5 feet to 6 feet apart.
   2) Light-wood-frame construction also includes "stud" framing that supports the roof.
   3) Toe nail joints with four ten-penny nails or framing fasteners.
   4) Diagonal braces for stability in vertical-bound side walls are used.
   5) Light-wood-frame construction provides a strong connection between the rafters and the lintel.

4. After the type of wall is determined--stud, pole, post, or metal--the siding type and attaching method need selecting. What type of siding is most popular in your area?

   What types of siding are used in farm structures?

   1) When the walls are up, they may only be the poles of a pole building; so if the supports are spaced wide apart, girts are needed to provide a nailing area. These cross pieces of wood are nailed between the posts, evenly dividing the height to be covered to insure secure nailing and strength from wind pressures.
   2) Galvanized steel, aluminum, block, wood siding, exterior plywood, and tempered hardboard are other types of siding used in farm structures.
   3) Metals have 25 to 50 years lifetime.
      a) High fire resistance
      b) No vermin problems
      c) Low maintenance
      d) Fasteners use washers and match metal types.
   4) Block siding lasts 50 or more years.
      a) High fire resistance
      b) No vermin problems
      c) Low maintenance
      d) Good paintability
   5) Three-fourths inch wood siding has a 50 plus years lifetime.
      a) Low fire resistance
      b) Subject to termites and rodents
      c) Low maintenance if siding is seasoned
      d) Good paintability as can use oil or latex paint
      e) Fastener types used are 2 1/2-inch to 3-inch

flat head, threaded, or common nails.

6) Three-eighth inch plywood (exterior grade) has an indefinite life if painted.
   - a) Low fire resistance
   - b) Subject to termites and rodents
   - c) Low maintenance if protected from weather
   - d) Good paintability for latex or oil paints
   - e) Fasteners used are 1 3/4-inch to 3-inch flat head, threaded, or common corrosion resistant nails.

7) Tempered hard board, 5/16 inch, has an indefinite life if painted.
   - a) Low fire resistance
   - b) Subject to termites and rodents
   - c) Low maintenance
   - d) Paintability good with oil
   - e) Fasteners used are 2-inch flat head, threaded, or common corrosion resistant nails.

8) Work from the ground up overlapping siding so water runs off. Seal cracks with waterproof caulking.

F. Summary

Walls are needed to support the roof, to resist lateral loads from inside the building, and to keep out the weather. Wood and sheet metal are the primary components of walls.

G. Evaluation

1. T
2. F
3. a. Lateral strength
   b. Vertical strength
   c. Protection
4. Any three of the following:
   a. Aluminum
   b. Galvanized
   c. Wood
   d. Block
   e. Hard board
   f. Plywood
5. Any two of the following:
   a. Aluminum
   b. Galvanized
   c. Block

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 8 - How are walls for farm buildings constructed?

EXAM

T F 1. Light-wood-frame construction supports the weight of the roof.

T F 2. Seasoned wood is not used in siding because of its ability to absorb large amounts of water.

3. What are the three purposes of walls?

   a.

   b.

   c.

4. Name three available siding materials.

   a.

   b.

   c.

5. List two sidings with high fire resistance.

   a.

   b.

81

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 9 - How are trusses designed and constructed?

Objective: Upon the conclusion of the lesson, students will be able to lay out and construct a truss for a farm building.

Study Questions:

1. What are the parts of a truss?
2. What determines your truss selection?
3. What are the materials used to construct trusses?
4. How are joints made during the construction of a truss?
5. Once cut, how is the truss constructed?
6. How are the trusses put into place and reinforced?
7. How are the roof and ceiling installed?

References:

1. Designs for Glued Trusses, by Midwest Plan Service, available from Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50
2. Transparencies
    a. TM-1: Parts of a Truss
    b. TM-2: Plywood Grade Stamps
    c. TM-3: Heel Gusset
    d. TM-4: Different Types of Gussets
    e. TM-5: Splices
    f. TM-6: Truss Jig
    g. TM-7: Nailing Diagram
    h. TM-8: Windbracing
    i. TM-9: Truss Anchorage
    j. Vis-9: Visual Aid Masters for MWPS #9 $2.50
3. Handouts
    a. HO-1: Summary Page
    b. HO-2: Ceiling Construction

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 9 - How are trusses designed and constructed?

TEACHING PROCEDURE

A. Review

B. Motivation: How many of you have seen a truss being built or installed? How does it get its strength? What holds it together?

C. Assignment: Find a truss and sketch its parts.

D. Supervised Study: Build a truss in the shop or build a miniature barn to scale.

E. Discussion

1. Use TM-1 to show the different parts that are important. Discuss the need of each part and its strengths.

   What are the parts of a truss?

   1) Panel points
   2) Gusset--ridge, web, heel
   3) Ridge
   4) Kingpost
   5) Chord--top, bottom
   6) Web--tension, compression
   7) Purlins
   8) Heel

2. There are numerous factors that will determine the type of truss you select.

   What determines your truss selection?

   1) In the Pratt web pattern, the more webs added the higher the load strength and the longer the span possibility.
      a) In a 2-web pattern, use 20 foot to 40 foot spans.
      b) In a 4-web pattern, use 34 foot to 60 foot spans.
      c) In a 6-web pattern, use 44 foot to 60 foot spans.
   2) Span is measured from the joint of the top and bottom chords.
      a) Limit of overhang is 2 feet.
   3) Roof slope affects the forces on the truss.
      a) 3/12 slope holds low snow loads.
      b) 4/12 slope is common.
      c) 5/12 slope is for a high load and long runs.

    4) Truss spacing is one per pole in 2-foot, 4-foot, or 8-foot spacings.
    5) Dead loads are determined per square foot of roof, ceiling, trusses, and braces.
    6) Snow loads are based on zones.
    7) Wind load minimum is set at 80 mph.
    8) Crane loads can be applied if weights will not stress the bottom chord.

3. Be sure to select the proper materials. Review the unit on woods to understand the terminology.

   What are the materials used to construct trusses?

   1) Lumber quality must be uniformly good.
   2) Grade classes of lumber
      a) Douglas Fir, Larch or Southern Pine 2 inches by 4 inches No. 2 SLF (MC 19%); 2 inches by 6 inches and larger No. 1 SJ and P (MC 19%)
      b) Hem-Fir same as a.
   3) Use only 2 inch by 4 inch and 2 inch by 6 inch in lower chords.
   4) Plywood for gussets is 3/8 inch or 1/2 inch. Review TM-1.
   5) Use only Group 1 wood species in out plies.
   6) Use casein or resorcinal resin glue.

4. Carefully lay out the cuts to be made. Check several times to avoid costly errors. Use TM-3, TM-4, TM-5.

   How are joints made during the construction of a truss?

   1) Select the gusset size from design tables (all web gussets are 3/8-inch plywood).
   2) Heel gussets cover the scarf cut. Face the grain parallel to the bottom chord. TM-3
   3) Web gussets cover the top chord by 4 inches and the entire width of the vertical web. TM-4
   4) Ridge gussets cover the full depth of the top chord.
   5) Lap joints connect the shortest web to the top chord and the king post to the bottom chord.
   6) Splices in chords are lapped and glue-nailed. TM-5

5. After all the parts are design-tested for strength and shape has been determined, the actual construction can begin. Do this to full scale or scale down for demonstration purposes using a jig.

   Once cut, how is the truss constructed?

1) Record dimensions and specifications before starting on summary page. TM-6
2) Assemble one truss according to the design tables.
3) Make a jig with 2-inch by 4-inch boards and plywood. TM-6
4) Take apart an assembled jig and use the parts for guides.
5) Double the web in cases of heavy snow or wind loads.
6) Assemble and glue using the jig.
    a) Use plenty of glue.
    b) Apply glue to both surfaces joined.
    c) Use 5d or 6d box nails spaced 2 inches apart across the grain and 4 inches apart with the grain. TM-7
    d) Glue should ooze.
7) Watch for dirt and temperature problems.
8) End wall trusses are sometimes built without outside gussets.

6. Once the trusses are built, they must be carefully put into place and secured. Centers must be carefully set to allow for sheathing.

How are the trusses put into place and reinforced?

1) Placing can be done by hand or by hoist one at a time spacing trusses 2 feet, 4 feet, or 8 feet apart on center.
2) Brace and anchor each truss to alignment. TM-8
    a) Place stiffeners along bottom chords.
    b) Cross brace king posts and at least every 16 feet at each end.
3) Anchorage resists uplift of roof. TM-9
4) Knee bracing stiffens wall and roof joint.

7. After the trusses are in place, framing and sheathing are needed to complete the overhead protection. Review plywood types and fasteners.

How are the roof and ceiling installed?

1) Framing and sheathing depend on the roofing material and truss spacing.
2) Sheathing plywood is most common. Use 6d nails to attach 1/2-inch plywood or less and 8d nails for plywood over 1/2 inch.
3) Leave 1/16-inch space between roof or wall panels and 1/8 inch between sides.
4) Space purlins according to table recommendations.
5) In high humidity, space ends 1/16 inch and 1/8 inch on sides.
6) Discuss. HO-2

F. Summary

Trusses are the backbone of a building. Their function is to support the roof, to withhold the weather, and to contain desirable environmental factors. Most trusses are purchased prebuilt for a particular structure.

G. Evaluation

Answers to Exam

1. F
2. F
3. Anchorage or knee bracing
4. Moisture expansion
5. Any five of the following:
   a. Panel points
   b. Gusset--ridge, web, heel
   c. Ridge
   d. Kingpost
   e. Chord--top, bottom
   f. Web--tension, compression
   g. Purlins
   h. Heel

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 9 - How are trusses designed and constructed?

EXAM

T F 1. A gusset is a plywood web.

T F 2. A truss jig helps to measure the pieces in the truss.

3. What is used to resist uplift from wind pressure?

____

4. Why leave a space between pieces of sheathing?

____

5. List five parts of a truss.

a.

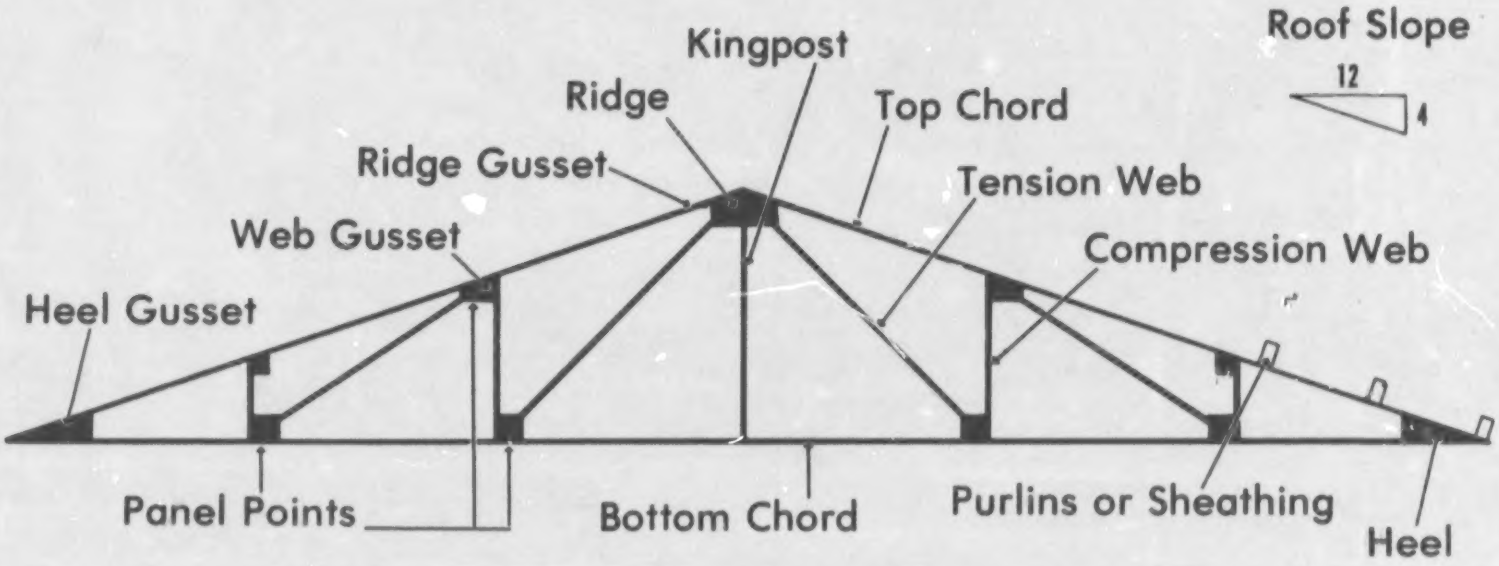
b.

c.

d.

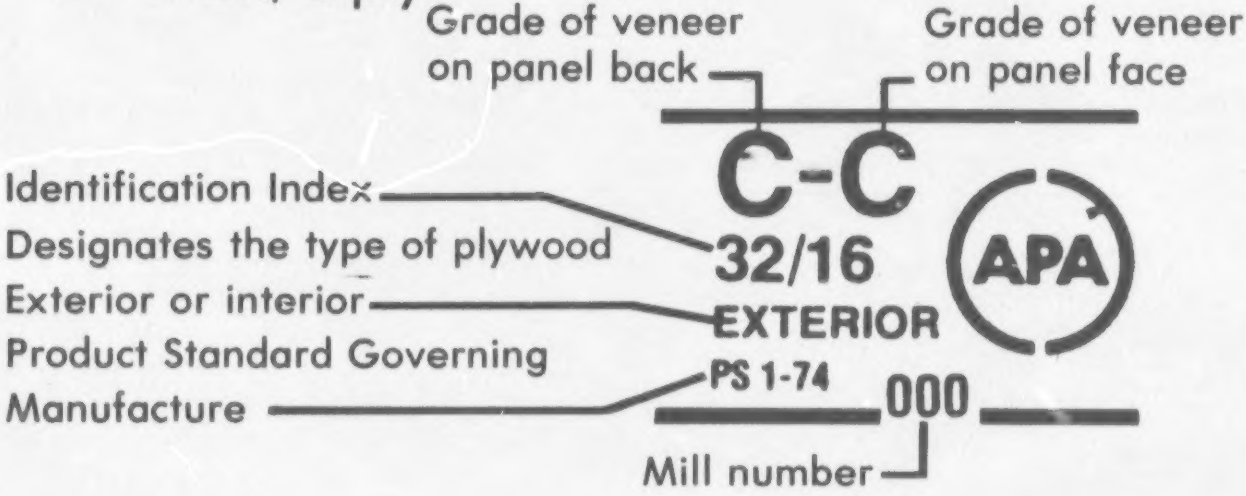
e.

Parts of a Truss

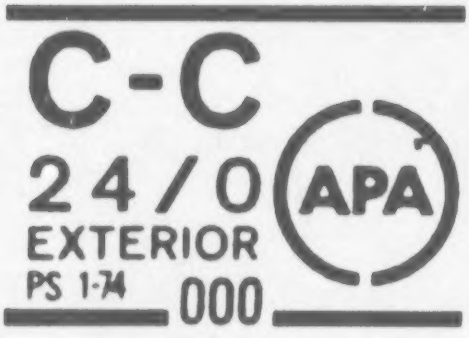

Roof Slope
12
4
Kingpost
Ridge
Top Chord
Ridge Gusset
Tension Web
Web Gusset
Compression Web
Heel Gusset
Panel Points
Bottom Chord
Purlins or Sheathing
Heel

Plywood Grade Stamps

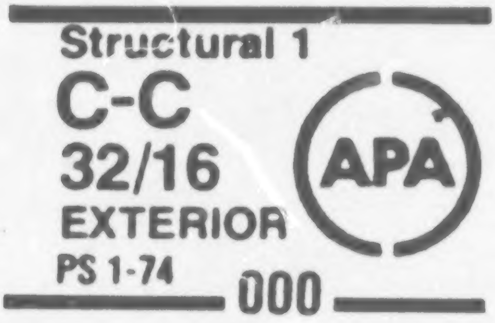
½" Thick, 5-ply


Grade of veneer on panel back
Grade of veneer on panel face
Identification Index
Designates the type of plywood
Exterior or interior
Product Standard Governing Manufacture
C-C
32/16
EXTERIOR
PS 1-74
000
APA
Mill number

³/₈" Thick, 3-ply


C-C
24/0
EXTERIOR
PS 1-74
000
APA

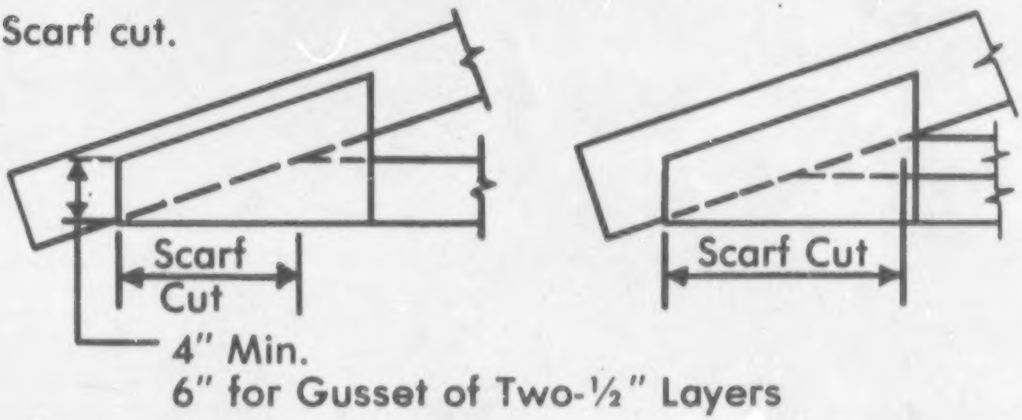
½" Thick, 4-ply


Structural 1
C-C
32/16
EXTERIOR
PS 1-74
000
APA

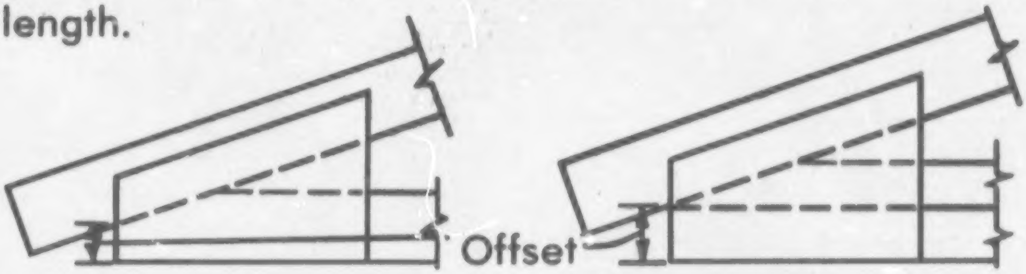
If 4-ply, must be "Structural 1."

Heel Gusset

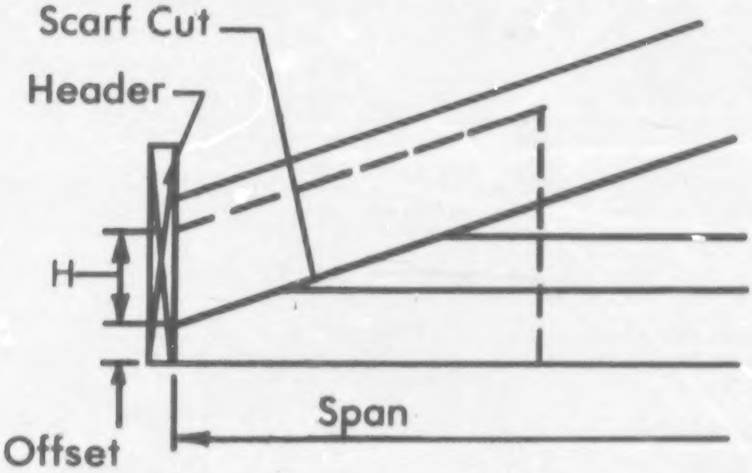
Scarf cut.


Scarf
Cut
4" Min.
6" for Gusset of Two-½" Layers
Scarf Cut

If the bottom chord is offset, increase the depth of the gusset the amount of the offset and use the tabulated length.

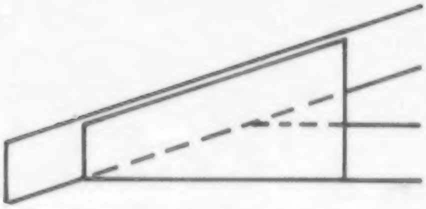


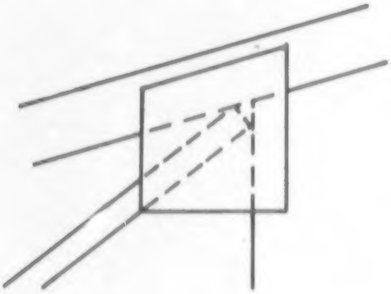
Scarf cut offsets to fix truss heel depth for sliding door header framing in pole buildings.

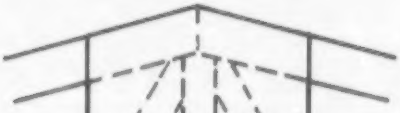

Scarf Cut
Header
H
Offset
Span

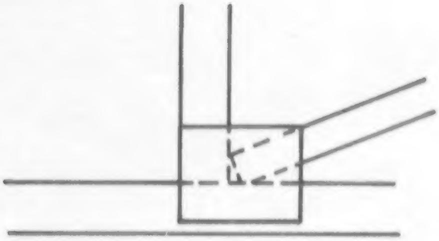
TM-4

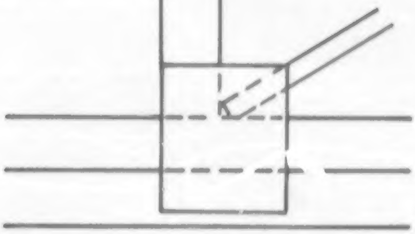
Different Types of Gussets

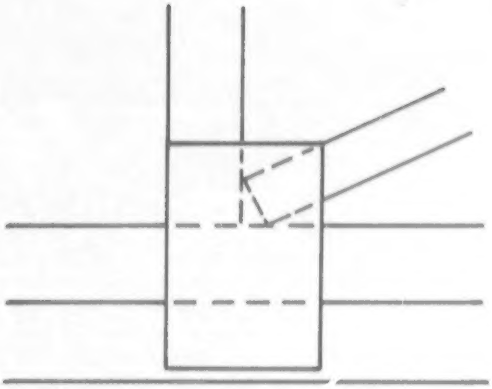






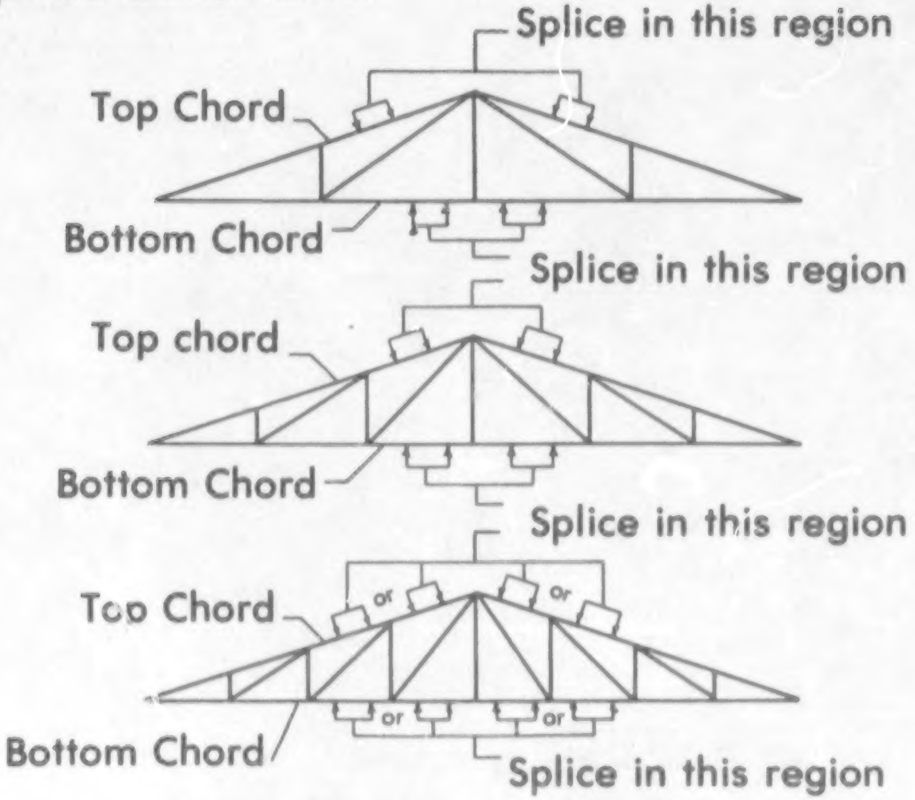




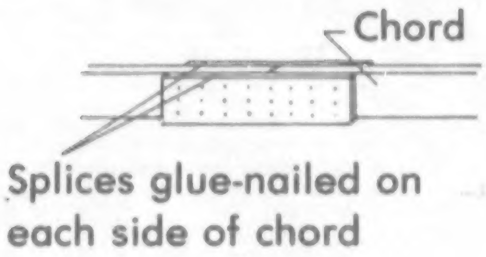


Splices

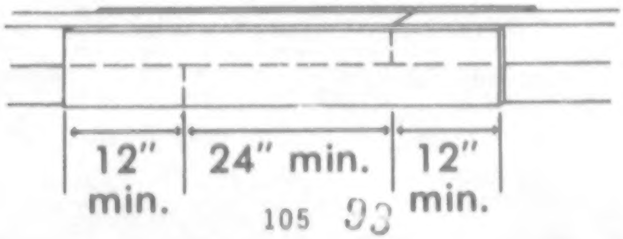
Splice Locations


Splice in this region
Top Chord
Bottom Chord
Splice in this region
Top chord
Bottom Chord
Splice in this region
Top Chord
or
or
Bottom Chord
or
or
Splice in this region

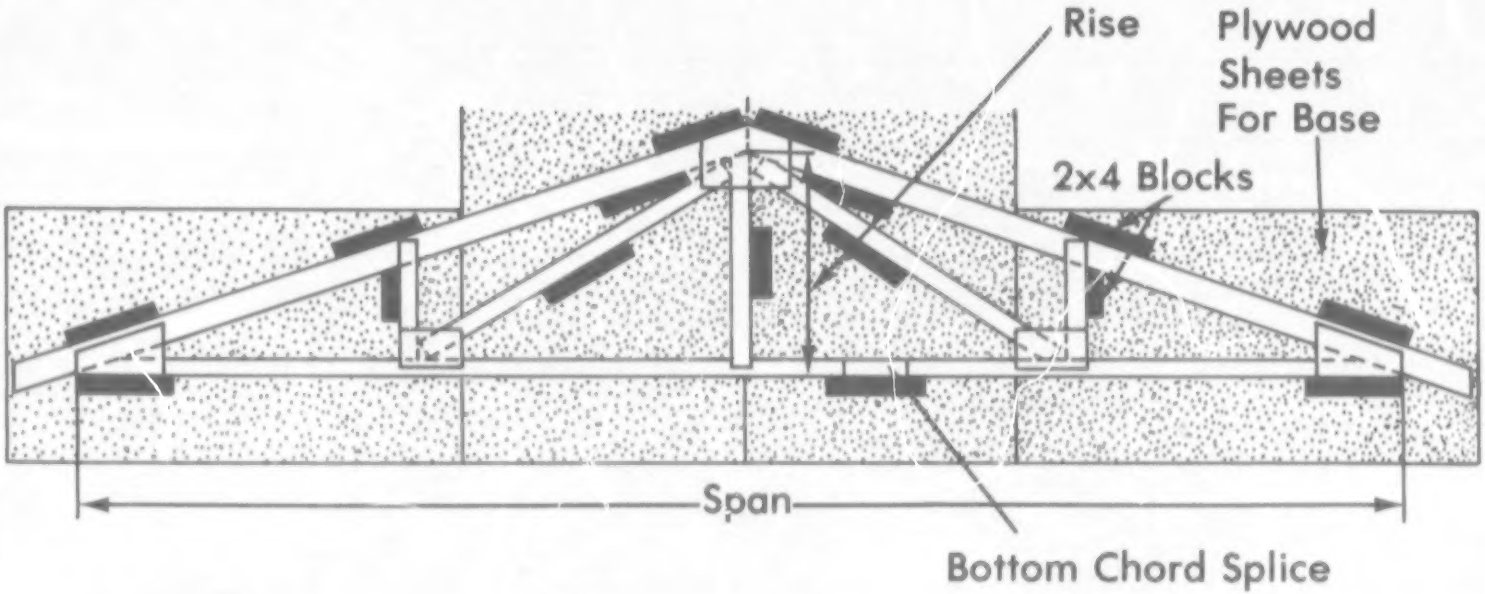
Top and Bottom Chord Splices


Chord
Splices glue-nailed on each side of chord

Splices for Stacked Bottom Chords


12" min.
24" min.
12" min.

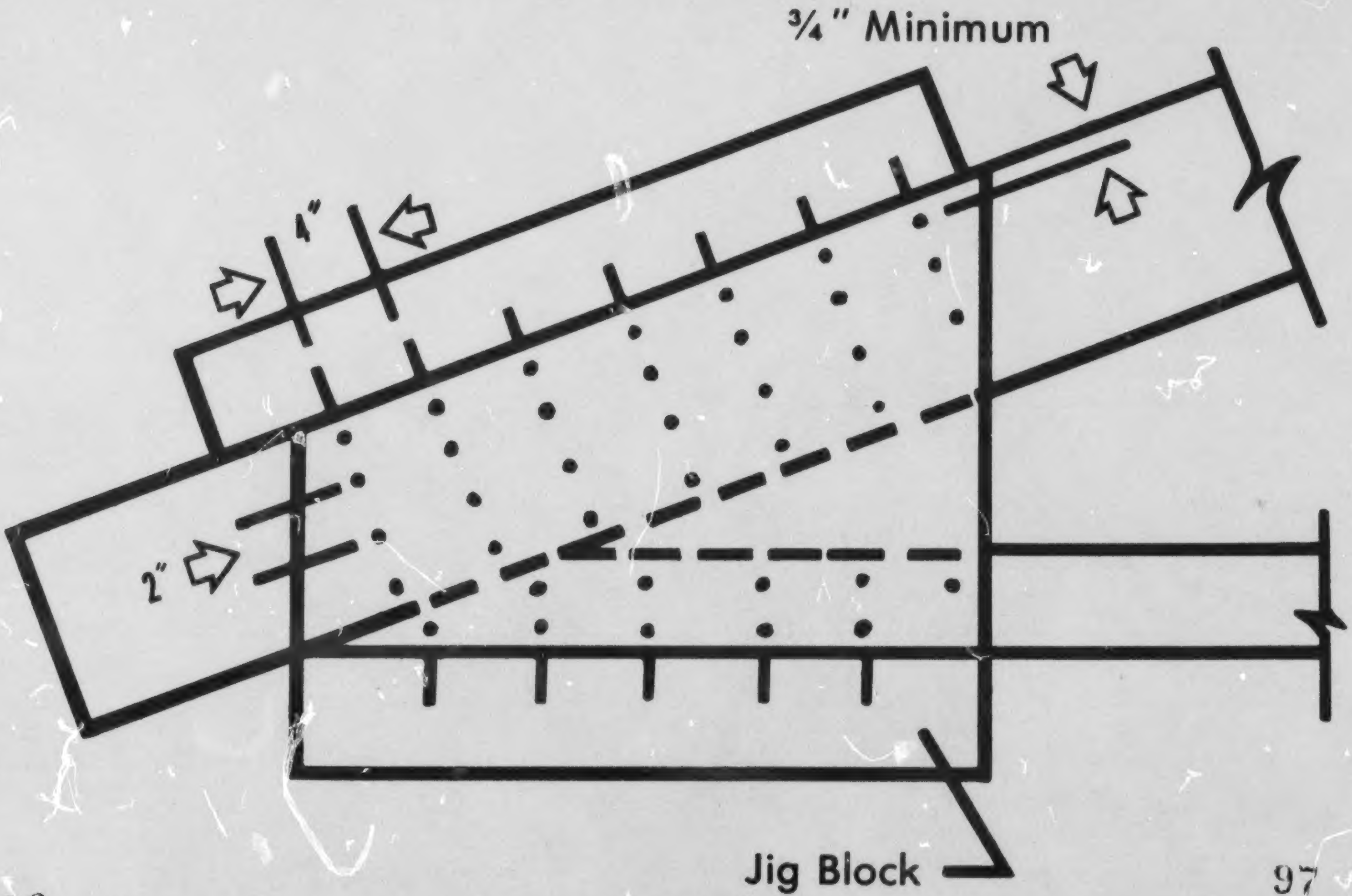
Truss Jig


Rise
Plywood Sheets For Base
2x4 Blocks
Span
Bottom Chord Splice

▨ Plywood Base ■ Blocks Nailed to Plywood

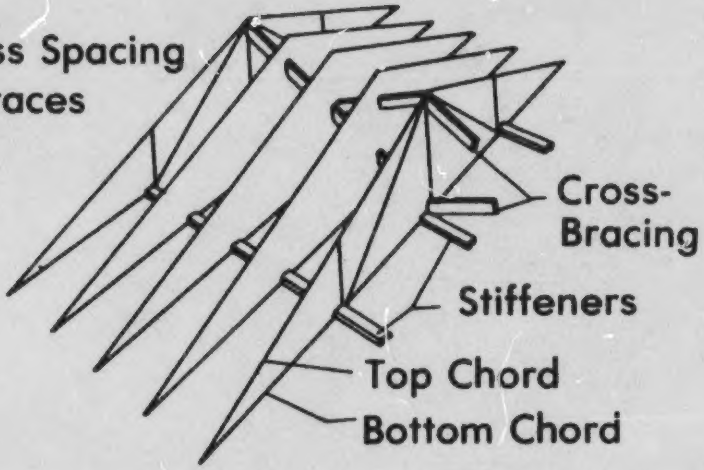
TM-6

Nailing Diagram

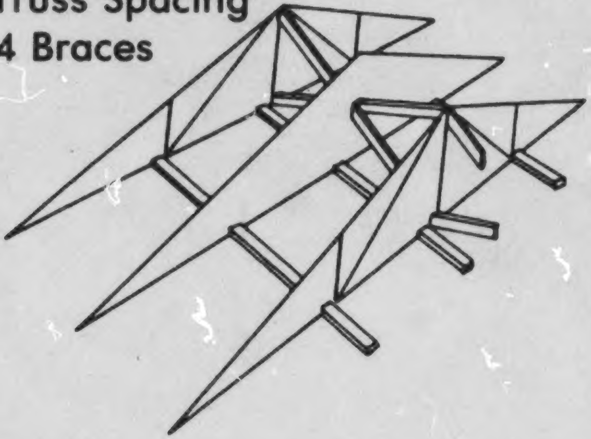

¾" Minimum
4"
2"
Jig Block

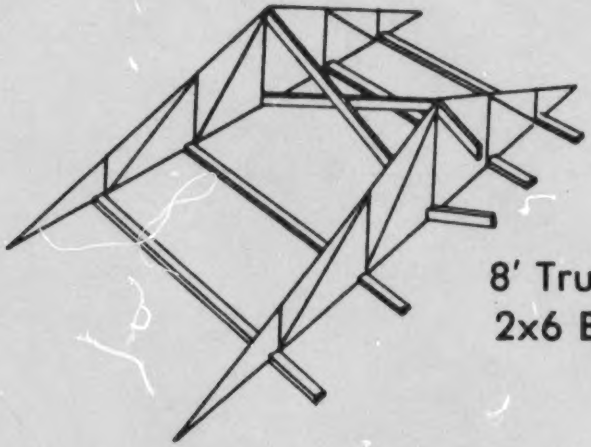
Windbracing

2' Truss Spacing
1x4 Braces


Cross-
Bracing
Stiffeners
Top Chord
Bottom Chord

4' Truss Spacing
2x4 Braces

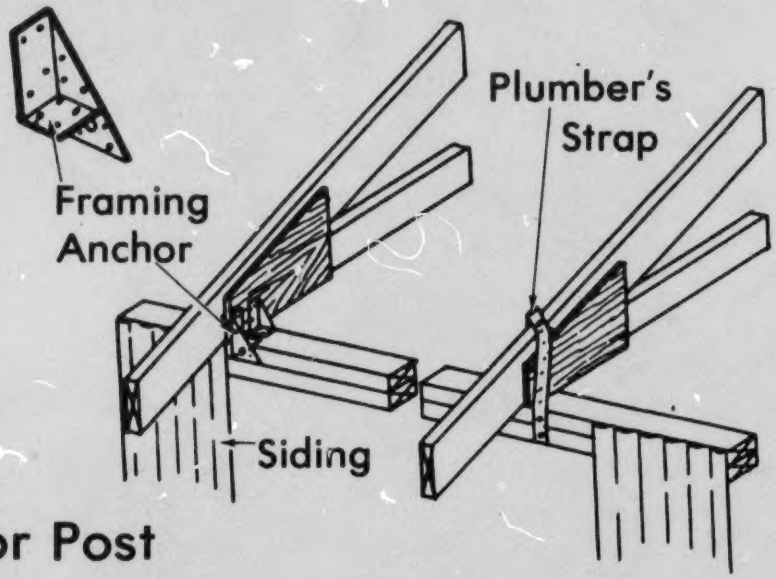




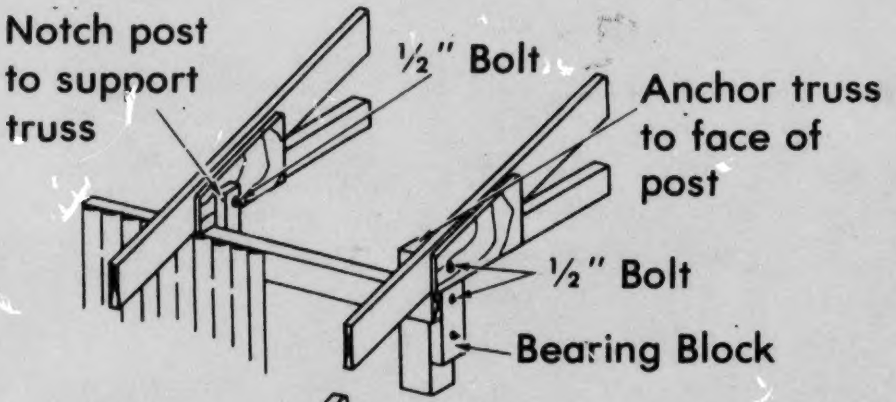
8' Truss Spacing
2x6 Braces

Truss Anchorage

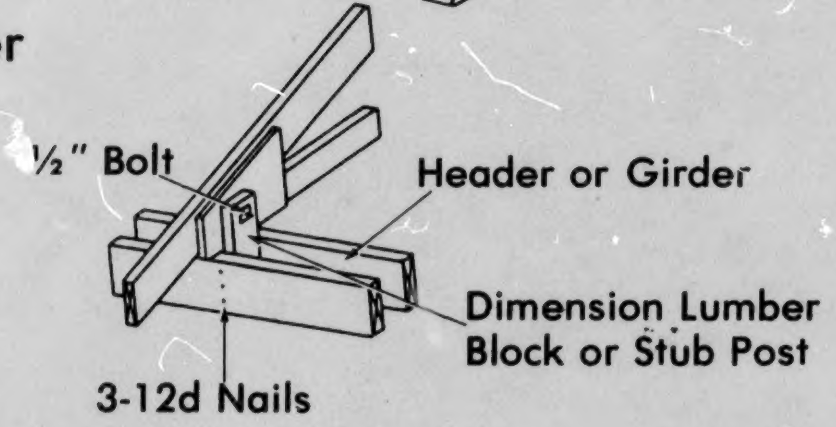
Plate


Framing Anchor
Plumber's Strap
Siding

Pole or Post

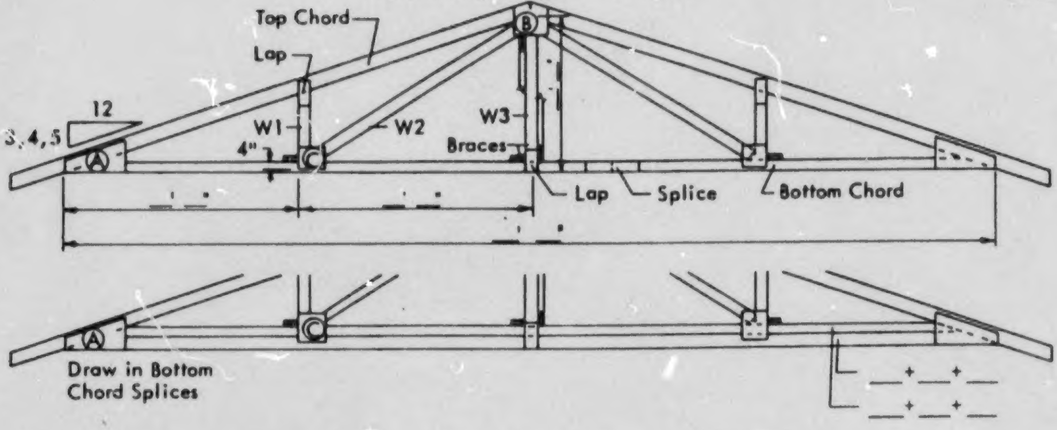

Notch post to support truss
½" Bolt
Anchor truss to face of post
½" Bolt
Bearing Block

Girder


½" Bolt
Header or Girder
Dimension Lumber Block or Stub Post
3-12d Nails

Summary Page 2-web

HO-1



Draw in Bottom Chord Splices

BOARD	DESCRIPTION	NO./ TRUSS	TOTAL/ BUILDING
Top Chord	2 x ___ x ___'	2	____
Bottom Chord	2 x ___ x ___'	—	____
	2 x ___ x ___'	—	____
	2 x ___ x ___'	—	____
	2 x ___ x ___'	—	____
W1	2 x 4 x ___'	2	____
W2	2 x ___ x ___'	2	____
	2 x ___ x ___'	2	____
W3	2 x ___ x ___'	1	____

Span ______________

Roof Slope ______________

Spacing ______________

Dead Load ______________

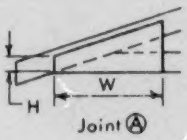
Snow Zone ______________

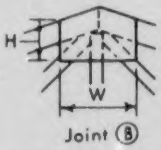
Lumber Species ________

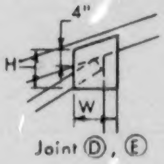
Dimensions
From page ________

No. Trusses Needed____

GUSSETS T = Thickness







JOINT	GUSSET SIZE, inches Thickness by Height by Width	NO./ TRUSS	TOTAL/ BUILDING
*A	______ x ____ x ______	4	____
B	3/8" x ____ x ______	2	____
C	3/8" x ____ x ______	4	____

*Check Heel Gussets, page 7, before final height (H) selection

Lap Joints**	______ x ____ x ______	6	____
Splice Joints**	______ x ____ x ______	______	____

**See page 8

Wind Anchorage The required number of bolts or framing anchors is listed on page 11.

Use _____ Anchors or_____ Bolts for each truss. TOTAL/BUILDING _______.

Wind Bracing Read pages 11 and 12 carefully. The bracing described is required for safety both during and after truss erection.

2x4 Bottom Chord Bracing 3 times building length = TOTAL lineal feet required _____ ft.

These braces must be the full length of the building. They are not needed in buildings that will have a rigid ceiling.

Cross Bracing 2 x ___ x ___ ft. TOTAL lineal feet required _____.

Knee Bracing 2 x ___ x ___ ft. TOTAL lineal feet required _____.

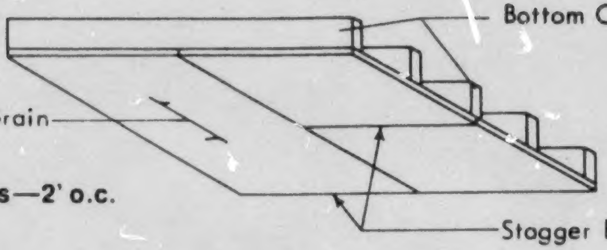
Roofing Material ______________ Consult your lumber dealer. Read ______________ pages 13 and 14 for the support needed.

Ceiling Material ______________ The material manufacturer will ______________ usually specify the framing to use.

Reproduced with permission from:
MWPS-9, Designs for Glued Trusses, 3rd Edition, 1978
Midwest Plan Service
Ames, IA 50011

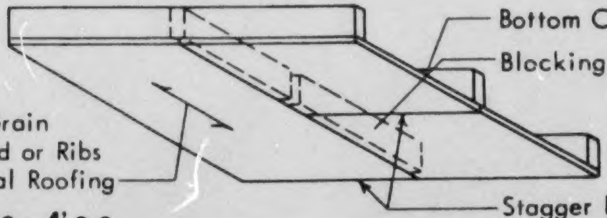
(Page numbers on this handout refer to reference for this lesson)

Ceiling Construction


Bottom Chords, 2' o.c.
Face Grain
Stagger End Joints

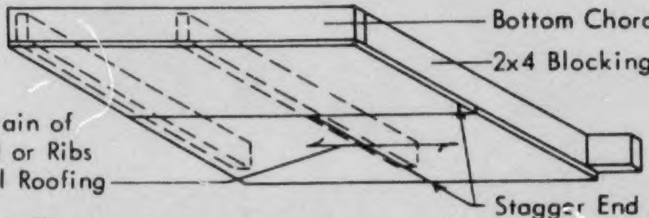
Trusses—2' o.c.

$\frac{3}{8}$" Plywood or $\frac{5}{8}$" sheetrock


Bottom Chord, 4' o.c.
Blocking between chords
Face Grain Plywood or Ribs of Metal Roofing
Stagger End Joints

Trusses—4' o.c.

$\frac{1}{2}$" Plywood without blocking, support edges with plyclips
or
$\frac{3}{8}$" Plywood with 2x4 blocking, 4' o.c.


Bottom Chords, 8' o.c.
2x4 Blocking, on edge, 4' o.c.
Face Grain of Plywood or Ribs of Metal Roofing
Stagger End Joints

Trusses—8' o.c.

$\frac{1}{2}$" Plywood with longitudinal blocking, support edges with plyclips
or
$\frac{3}{8}$" Plywood with blocking on all edges

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 10 - What roofing materials are commonly used and how are they attached?

Objective: Upon the conclusion of the lesson, students will be able to identify, list the characteristics, and attach the different types of roofing available.

Study Questions:

1. What types of roofing are available and most practical for farm buildings?
2. What are the characteristics of galvanized steel roofing?
3. How is galvanized steel roofing attached?
4. What are the characteristics of aluminum roofing?
5. How is aluminum roofing attached?
6. What are the characteristics of asphalt shingles?
7. How are asphalt shingles attached?

References:

1. Utility Buildings, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Practical Farm Buildings, available through The Interstate Printers & Publishers, Inc., Danville, IL 61832 $7.95

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 10 - What roofing materials are commonly used and how are they attached?

TEACHING PROCEDURE

A. Review

B. Motivation: What types of roofs are used extensively in farm buildings? Which are easiest to attach? Which have a longest life span?

C. Assignment: Find out what type of roofing is most commonly used in your area and how it is attached.

D. Supervised Study: Set up comparison charts and strength tests between the different types of roofing material.

E. Discussion

1. Have samples of the various types of roofing used on farm buildings in your area available for inspection. Discuss the value of each material.

   What types of roofing are available and most practical for farm buildings?

   1) The three most popular types of roofing are: asphalt shingle, galvanized steel, and aluminum.
   2) The easiest roofing to apply is either galvanized steel or aluminum.
   3) Roofing needs to keep out rain, wind, and snow and provide protection from the sun.

2. Galvanized steel is very popular and generally easy to maintain and resist the elements. Are they used in your area?

   What are the characteristics of galvanized steel roofing?

   1) Galvanized steel roofing is usually 28 gage with 1.25 ounces of zinc per square foot.
      a) It will last up to 15 years before the first rust.
      b) Its life is 45 years.
      c) It is fire resistant.
      d) It is hail resistant.
      e) It is heat resistant.

        f) It is also wind resistant if properly installed.
        g) To maintain roofing, recoat with zinc paint if rust appears.
        h) Minimum slope is 3 to 4 inches per foot.
        i) It has low corrosion resistance to salt and fumes.
        j) It is low to medium cost.
    2) Galvanized steel roofing is also 26 gage with 2 ounces of zinc per square foot.
        a) It may be up to 23 years before the first rust appears.
        b) It has 50 plus years of life.
        c) Other factors are the same as 28 gage galvanized steel roofing.
    3) Sizes are 24 inches to 30 inches wide and as long as 30 feet.

3. Attaching the roofing is as important as proper maintenance. What methods are used to attach the roofing? What factors need consideration?

    How is galvanized steel roofing attached?

    1) Use screw or ring shank nails that are 9 or 10 gage and 2 to 3 inches long.
    2) Use galvanized nails with neoprene or lead washers.
    3) Strength depends on the steel pattern, thickness, and spacing of girts.
    4) Start laying sheeting at lower corner on end away from the strongest winds.
    5) Lap one and one-half corrugations.
    6) Use 6-inch to 9-inch end laps.
    7) V crimps need 12-inch spaced roof girts.
    8) One and one-fourth inch corrugated roofing needs 24-inch spaced roof girts.
    9) Two and one-half inch corrugated roofing needs 36-inch spaced roof girts.
    10) Do not overdrive nails; use 1 to 1 1/4 pounds of nails per square foot of roofing.

4. Aluminum is now catching up with galvanized sheeting as a widely used roofing material. What are its advantages over other types of building materials?

    What are the characteristics of aluminum roofing?

    1) It has a probable life of 50 plus years.
    2) Fire resistance is good.
    3) Hail resistance is fair with light metal; hail resistance is good with backing or over .019 inch thickness.
    4) It has excellent heat resistance.
    5) Wind resistance is fair.
    6) Sheets need to be well nailed to maintain roofing.

7) Minimum slope is 4 inches per foot.
8) It has poor corrosion resistance to salt and fumes.
9) It is medium cost.

5. What methods are used to attach roofing made of aluminum?

How is aluminum roofing attached?

1) Use screw or ring shank aluminum nails with neoprene washers that are 11 gage and 1 1/2-inch to 1 3/4-inches long.
2) Roofing sheets are 24 inches, 30 inches, and 48 inches wide and up to 24 feet long.
3) Start on leeward side of building.
4) End lap 6-inch roof.
5) Side lap 1 1/4-inch corrugation.
6) Use 100 nails per square of roof.
7) When aluminum is used in combination with all other metals, care should be taken to prevent galvanic action.
8) If a steel frame is used, use a primer coat plus a heavy coat of aluminum or other high-quality paint. Or use wood purlins to avoid contact with steel frame.

6. Have samples of the types of shingles available in the community. Also use a sheet of plywood and have the students lay rows of shingles.

What are the characteristics of asphalt shingles?

1) Life of asphalt shingles is 7 to 25 years.
2) Asphalt shingles will burn after a build up of heat.
3) They are fairly hail resistant.
4) They are fairly heat resistant from sun.
5) They have fair resistance to strong wind.
6) Maintenance may be needed due to damage from a strong wind or hail.
7) Roof slope should be 5 inches per foot.
8) They have good corrosion resistance to salt and fumes.
9) Cost is low to medium.
10) Three hundred pounds per square of ten is used.
11) Asphalt shingles are made of felt that is asphalt coated with granite chips.

7. Care must be taken to apply the shingles correctly to prevent leaks and other problems.

How are asphalt shingles attached?

1) First, nail metal started strip to eave extending beyond wood trim 3/8 inch to 1/2 inch so water will not hit wood.
2) Use ring or barbed, galvanized steel nails with 1/2-inch head and 1 1/4 inches long or long enough to penetrate sheathing.
3) First row at eave is 9 inches to 36 inches wide and nailed to solid roof deck.
4) Use six large-head nails per 3 foot strip containing three 12 inch shingles.
    a) One nail is placed 1 inch back and 1 1/2 inches on each side of notch.
5) High wind areas need special tie-down shingles.

F. Summary

The three common types of roofing used on farm structures are galvanized steel, aluminum, and asphalt shingles. Care in attaching these types of roofing will prevent problems in the future.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. a. Galvanized steel
   b. Aluminum
   c. Asphalt shingle
6. a. Steel pattern
   b. Thickness
   c. Spacing of girts

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 10 - What roofing materials are commonly used and how are they attached?

EXAM

T F 1. Zinc is a rust preventive used on aluminum roofing.

T F 2. Galvanized roofing is cheaper to apply than aluminum roofing.

T F 3. Screw or ring shank nails with washers are recommended for asphalt shingles.

T F 4. The major problem with asphalt shingles is wind and hail damage resistance.

5. List the three most popular types of roofing.

   a.

   b.

   c.

6. What factors affect the structural strength of aluminum roofing?

   a.

   b.

   c.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 11 - How are farm utility buildings constructed?

Objective: Upon the conclusion of the lesson, students will be able to read plans, to identify materials, and to identify types of utility buildings.

Study Questions:

1. What are the advantages of a post-free utility building.
2. What are the types of buildings and the causes of their failure?
3. What type of roof framing should be used?
4. What type of foundation and wall support should be provided?
5. What kind of roofing material should be used?
6. What kind of siding material should be used?
7. How are doors selected?
8. How is the type of floor selected?
9. How is the kind of paint selected?
10. What provisions should be made for lightning protection?

Reference:

1. Utility Buildings, by AAVIM, available from IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 11 - How are farm utility buildings constructed?

TEACHING PROCEDURE

A. Review fasteners and wood protection.

B. Motivation: How many students have seen a building collapsed or shifted by the wind? How many have seen wood in a building rotted by water?

C. Assignment

D. Supervised Study

E. Discussion

1. Draw comparisons between buildings with internal posts to buildings with wall support for ease of movement and workroom inside the building. Discuss the adaptability of the buildings.

   What are the advantages of a post-free utility building?

   1) Space is easily divided.
   2) There is a wide selection of arrangements for fitting equipment in available space.
   3) There is flexibility for livestock divisions.
   4) Ample space for trucks is advantageous.
   5) It is easier to service equipment.

2. Draw the basic shapes of the buildings on the board and discuss the advantages of each in respect to weather and use.

   What are the types of buildings and the causes of their failure?

   1) Shed-type building has a slanted roof with one side open.
   2) Gable-type building has a double slant roof with end and side openings.
   3) Curved half-arch building has a curved roof with a side entrance.
   4) Curved full-arch building has a curved roof (half round) and an end entrance.
   5) Umbrella building has a double slant roof with no sides or end.
   6) Buildings fail because of weak joints or improper bracing.

7) Weakest point of a building is where two or more members are joined.
    a) Members may be joined by soil to foundation.
    b) Members may be joined by post on piers.
    c) Members may be joined by rafters or trusses on plates, side walls, or columns.
    d) Roof ridge members may be joined.
8) Inadequate foundation problems may be the downfall of a building.

3. The type of roof framing will vary according to the needs of the building. Select a type of building, i.e., livestock, and discuss which type of roof is needed. Use page 8 of the reference as a guide. Discuss feed storage as a part of the building.

What type of roof framing should be used?

1) Types of farm-built framing
    a) Common rafter
    b) Truss
    c) Truss-high clearance
    d) Umbrella truss
    e) Curved-arch rafter
    f) Rigid wood frame
2) Types of commercial framing
    a) Steel frame--narrow
    b) Laminated rafters
    c) Rigid-steel frame
    d) Frameless steel
3) Factors to consider in selection
    a) Post-free width
    b) Extra height
    c) Loads
    d) Provisions for strong joints
    e) Roofing
    f) Quality of framing
4) Post-free width will determine use of rafters, trusses, curved arch, rigid, or all-steel building.
5) Roof framing needs to provide for extra height for machinery.
6) Snow, dead, live, wind, and hoist loads determine type of roof framing.
7) Provisions for strong joints are strength factors, listing from the best to the worst.
    a) Phenolic-resin glue holds up to 13,210 pounds.
    b) Split-ring connectors provide for 10,010 pounds.
    c) Two and one-half inch bolts carry 6,800 pounds.

    - d) Eight 16d nails holds up to 3,100 pounds.
  - 8) Provisions recommended for attaching different kinds of roofing are:
    - a) Galvanized steel or aluminum open-slat and purlin decking
    - b) Wood shingles sheathing 1-inch boards 4 to 6 inches wide spaced on centers
    - c) Asphalt roofing needs solid decking tongue and grooved or plywood.
    - d) Asbestos-cement shingles
    - e) Asbestos-cement corrugated sheets
  - 9) Quality of framing required is presented in Table III on page 20 of the reference.

4. Discuss the relative strength of different foundation methods used, refering to page 22 of the text for examples.

   What type of foundation and wall support should be provided?

   - 1) Common types of supports
     - a) Wood or steel poles; or posts and piers
     - b) Post and girt with masonry or concrete
     - c) Masonry walls on concrete
     - d) Steel
     - e) Combinations
   - 2) Resistance to wind and weight bracing should be provided to:
     - a) Resist settling
     - b) Resist soil movement
     - c) Resist uplift and overturning force of wind
   - 3) Provisions for attaching siding is considered.
   - 4) Resistance to vermin and decay is met by:
     - a) Pressure treatment of poles
     - b) Splash boards
   - 5) Fire resistance check should be made as to the:
     - a) Tendency to burn
     - b) Rate of spread
     - c) Strength of members under intense heat
   - 6) Ease of construction from the easiest to hardest is:
     - a) Pole type
     - b) Shed-gable and arch-framed

5. Have samples of roofing materials on hand to show to the class. Explain each one at a time and compare each sample. Try to reach a consensus.

What kind of roofing material should be used?

1) Consider the following factors
    a) Life expectancy
    b) Fire resistance
    c) Hail resistance
    d) Resistance to heat from sun
    e) Resistance to strong winds
    f) Maintenance
    g) Minimum roof slope
    h) Weight
    i) Nailing required
2) Discuss the quality chart on page 33 Table V of your text.
3) The quality of galvanized-steel roofing is determined by its thickness and zinc coat.
4) Quality of aluminum depends on thickness.
5) Wood shingles use No. 1 grade made from heartwood.
6) Asphalt varies.
7) Nail with ring or screw shank nails with neoprene gaskets.

6. Try to arrange for siding samples or visit local utility buildings to see the sidings used.

What kind of siding material should be used?

1) Factors to consider when selecting siding material
    a) Life expectancy
    b) Fire resistance
    c) Resistance to vermin
    d) Maintenance
    e) Paintability
    f) Type of fastener
2) Discuss the factors in Table VII on page 38 of your text as related to cost.
3) Maintenance is determined by the quality of materials and construction.

7. The placement and selection of the doors will be determined by use. Large doors are used for machinery and small ones are used for livestock and people.

How are doors selected?

1) Single or double sliding doors are inexpensive.
2) Overhead doors cost more and sizes are limited.

8. Usage will determine the type of floor to be used. Cleaning is easier with floors kept dry; so concrete is well suited.

How is the type of floor selected?

1) Dirt floor is the cheapest, but a dirt floor makes it hard to anchor machinery. Dirt gets into equipment, and the floor is hard to clean without lowering it.
2) Crushed rock holds dirt and grease and is an uneven floor.
3) Concrete forms a hard, dry surface which is easy to clean and secure machinery. It is fireproof and permanent. Floor stays level so there is a need for drains and a slope to remove water.

9. Paint sample pieces of wood and run temperature, moisture, and other stress tests to determine the durability of the paints.

How is the kind of paint selected?

1) Paint can keep moisture out or trap moisture in woods.
2) White or light colors can reflect 70% of the sun's heat.
3) Light colors have a shorter life span.
4) Review Table VIII on page 44 of your reference.
5) Look for these characteristics.
    a) Durability (4 to 8 years)
    b) Self-cleaning
    c) Highly reflective
    d) Dirt resistance
    e) Moisture sensitivity
    f) Stain resistance
    g) Good hiding qualities

10. A need for good lightning protection must be planned in advance of construction.

What provisions should be made for lightning protection?

1) Lightning can be handled by grounding a metal roof or using lightning rods.
2) Draw the 3 systems on page 45, Figure 50, on the board or discuss from the text.

F. Summary

When building a utility structure on the farm, plan the building carefully to the specifications needed in your area.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. Any three of the following:
    a. Shed
    b. Gable
    c. Curved half
    d. Curved full-arch
    e. Umbrella
5. Any four of the following:
    a. Life expectancy
    b. Fire, hail, heat, and wind resistance
    c. Maintenance
    d. Roof slope
    e. Weight
    f. Nailing

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 11 - How are farm utility buildings constructed?

EXAM

T F 1. The weakest point of a structure is where two or more members are joined.

T F 2. Phenolic-resin glue has the highest bonding power of the fasteners.

T F 3. Metal roofs are grounded to the earth by the framing members.

4. List three types of buildings.

    a.

    b.

    c.

5. List four factors to consider when selecting roofing materials.

    a.

    b.

    c.

    d.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 12 - What are the factors to consider when planning swine housing and equipment?

Objective: Upon the conclusion of the lesson, students will be able to select buildings and equipment for the different swine systems.

Study Questions:

1. What are the production alternatives for the swine producer?
2. How does the type of swine system affect building selection?
3. What is the role of ventilation in the construction of swine facilities?
4. What are some examples of ventilation and heating systems?
5. How is the swine manure handled?
6. How are slats and gutters constructed?
7. What materials and fasteners are used in swine building construction?

References:

1. Swine Handbook Housing and Equipment, by Midwest Plan Service, available from Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50
2. Transparency:
    a. Vis-8: Visual Aid Masters for MWPS #8 $4.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 12 - What are the factors to consider when planning swine housing and equipment?

TEACHING PROCEDURE

A. Review waste management and basic construction.

B. Motivation: What are the advantages of confinement swine systems? How do you reduce the stress on each animal? What is the proper method for handling swine?

C. Assignment

D. Supervised Study: Visit a well-planned swine facility in the community. Then outline the facility on the board and discuss the points of interest.

E. Discussion

1. Discuss the differences between the systems in respect to facilities and storage of feeds. With the clues, compare the systems.

   What are the production alternatives for the swine producer?

   1) Product to be marketed
      a) Feeder pigs
      b) Farrow to finish
      c) Buying feeders and finishing
   2) Pasture vs. confinement
   3) Building location--drainage, expansion, and accessibility
   4) Building systems
      a) One-stage production
      b) Two-stage production
      c) Three-stage production
      d) Others

2. Quickly review the different swine management systems: farrowing, growing, finishing, and gestation. On the board list the unique needs of each system and relate these needs to needs for the building layout.

How does the type of swine system affect building selection?

Farrowing

1) Farrowing schedules
   a) One litter a year
   b) Two litters a year
   c) Multiple litters a year
2) Environmentally controlled farrowing buildings
3) Farrowing stall sizes
4) Farrowing pen sizes
5) Free stall systems
   a) Advantages of free stall
   b) Disadvantages of free stall
6) Slotted floor spacing and cleaning
7) Solid floor slope for ease of cleaning
8) Area to wash sows
9) Questions to ask when selecting a layout
   a) Is manure solid or liquid?
   b) Sows feed in or away from pens?
   c) Feed in outside or inside alley?
   d) Will stall or pen be used for growing?
10) Look through the diagrams on pages 9 to 11 of your reference and note the methods of layout used.

Growing

1) Control the environment carefully to 60°F; 50% to 80% humidity; adequate space, feed, and water.
2) Space 3 to 4 square feet per pig to 100 pounds; 1 waterer for 20 to 25 pigs; and 1 feed space for every 4 pigs.
3) Floor plan design should include provisions for numbers, feeding, and manure handling.

Finishing

1) Pigs' weights range from 100 pounds to market weight.
2) Watch for tail biting and cannibalism.
3) Space 6 square feet for each 100 pounds of pig and up to 8 square feet when the pig weighs 150 pounds.
4) Limit 25 pigs per pen.
5) One waterer for every 20 to 25 pigs and 1 feed space for every 4 pigs.
6) Slope the floors.
7) Selection factors for swine building include manure handling and location of feed and water sources.
8) Look at the plans in the reference for examples of construction.

Gestation

1) In gestation there is a high investment in building and equipment.
2) In open shelter housing, allow 15 square feet of bedding per sow.
3) Keep temperatures inside and out equal in open shelter.
4) Check examples on page 16 of your reference.
5) In confinement, use slotted floors to eliminate bedding; allow 15 to 20 square feet per sow.
6) Breeding should be done on solid floors or in sand in a separate pen.
7) Slots of 1 inch to 1 1/4 inch between 4-inch to 8-inch wide slats are best.
8) Tie sows into stalls to control feeding and save space.
9) Separate feeding stalls to prevent bossiness.

Pasture

1) Pasture allows a lower investment and less climate control.
2) Use slabs under feed and water to prevent wallows.
3) Remember shade requirements.

3. Review the unit on insulation and vapor barriers to be sure the students understand the basic principles. Use a fan in class to show air movement (smoke will help). Draw a comparison with an exhaust fan.

What is the role of ventilation in the construction of swine facilities?

1) There are four functions of ventilation.
    a) Remove moisture
    b) Remove odors
    c) Provide fresh air
    d) Remove excess heat
2) Ventilation is a process of exchanging air, requiring:
    a) Fans to move air
    b) Inlets to distribute air
    c) Outlets to exhaust air
    d) Automatic controls
3) Successful ventilation requires:
    a) Insulation
    b) Vapor barrier
    c) Supplemental heat
    d) Management and maintenance
4) Ventilation needs effective insulation based on the area and "R" value.

5) Ventilation needs a vapor barrier to eliminate the flow of moisture.
6) Fan selection
   a) Construction features should include sealed motors, automatic shutters, and corrosion resistance.
   b) Speed features require variable speeds with an automatic control.
   c) Select the fan for the capacity of the job that can move enough air for both "minimum" winter, "normal" winter, and summer.
   d) Locate the fans away from inlets and prevailing winds.
7) Air inlets and outlets rely on pressure to control air flow.
8) Slots inlets can be installed on the sides (eaves) or in the ceiling to draw attic air during the winter (roof heated) or eave air in summers.
9) Duct inlets are used in small buildings with one fan. They help distribute air evenly.
10) Duct outlets draw low cold air or high warm air.
11) Manure pit outlets control odor and eliminate dangerous gases.
12) Summer inlets are large openings for larger air flow.

4. Put together the components of the ventilation system for a balanced load at low cost.

What are some examples of ventilation and heating systems?

1) Exhaust systems pull air from the building, sucking air in inlets.
2) Pressure systems blow air into buildings.
3) Individual blowers blow air into each stall which is easily controlled.
4) Control ventilation by:
   a) Fan speeds
   b) Partial recirculation
   c) Air baffles
   d) Clock or thermostat control
5) Emergency control systems are needed to prevent livestock loss.
6) Heating is added for animal comfort and moisture removal.
7) Use brooder lamps for nursing areas. One hundred fifty-watt bulbs are used in the winter and 40-watt bulbs are used in the summer.

8) Warm air can be used to heat under the floor.
9) Underfloor heat cables can be used.
10) Underfloor hot water systems are available.
11) Cooling methods
    a) Evaporation
    b) Mechanical
    c) Spray

5. The handling of manure from swine is an ever increasing problem for the producer. Discuss the different forms in which it is handled and the problems associated with it.

How is the swine manure handled?

1) Careful management is needed to:
    a) Maintain animal health
    b) Avoid pollution
    c) Comply with local, state, and federal regulations
2) Solid manure handling requires:
    a) Solid floors
    b) Minimum of equipment
    c) Area to spread solids
3) Liquid manure is used because:
    a) Minimal time and labor is required.
    b) Spreading can be postponed.
    c) Covered storage may be utilized to control odors.
4) Types of liquid storage include:
    a) Lagoon
    b) Oxidation ditch
    c) Settling basin
    d) Holding pond
5) Gases produced:
    a) Methane
    b) Carbon dioxide
    c) Ammonia
    d) Hydrogen sulphide
6) Storage is determined by number of animals times the daily manure times the storage time in days and extra water.
    a) Locate storage downhill at 100 feet minimum.
    b) Get permission before building.
7) Slope gutters and pits.
8) Agitate manure before removal to suspend solids.
9) Dispose by field spreading.
10) Carefully control runoff to prevent pollution.

6. Explain the difference between concrete, wood. steel, aluminum, and plastic in terms of strength, wear resistance, and weight.

   How are slats and gutters constructed?

   1) Heavier slats (concrete) require heavier supports and are harder to handle.
   2) Use redi-mix to cast slats. Ask for 7 1/2 bag mix with slump of 2 inches to 3 inches, maximum aggregate size of 1/2 inch, and air entrained concrete with 28-day strength of at least 3,500 psi.
   3) Space slats according to need.
   4) Reinforce the slats with 2 bars.
   5) Design holders to prevent movement.
   6) Use joists for wide slats.

   Look through diagrams from pages 42 to 75 in the reference, especially noting the sections on fencing and waterers.

7. The construction materials used are outlined on pages 76 to 82 of the reference.

   What materials and fasteners are used in swine building construction?

   1) Wood
   2) Pressure-treated wood preservatives
   3) Plywood
   4) Lead-free paint
   5) Galvanized sheet metal
   6) Masonry foundations
   7) Concrete construction
      a) Reinforcing
      b) Pouring
      c) Curing
   8) Fasteners
      a) Nails
      b) Screws
      c) Glue

F. Summary

The swine facilities can vary from simple shade structures to intricate confinement systems. Pay particular attention to waste handling and ventilation when planning a swine structure.

G. Evaluation

Answers to Exam

1. F
2. T

3. T
4. F
5. F
6. T
7. T
8. a. Remove moisture
   b. Remove odors
   c. Fresh air
   d. Remove heat
9. a. Odors
   b. Gases
10. a. Evaporation
    b. Mechanical
    c. Spray

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 12 - What are the factors to consider when planning swine housing and equipment?

EXAM

T F 1. Confinement systems are cheaper to build than pasture units.

T F 2. Slotted floors are easier to keep clean.

T F 3. Solid floors need to be sloped to ease cleaning.

T F 4. Finishing hogs require a waterer per 40 hogs and a feed space per 8 hogs.

T F 5. Breeding can be accomplished easily on slotted floors.

T F 6. An advantage to liquid manure is its low labor costs.

T F 7. Methane gas is flammable and a byproduct of manure breakdown.

8. What are the four functions of ventilation?

a.

b.

c.

d.

9. Manure pit ventilation outlets control:

a.

b.

10. The three cooling methods for facilities are:

a.

b.

c.

126

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 13 - How is building lumber made and selected for use in farm structures?

Objective: Upon completion of this lesson, students will be able to identify, select, and quality check lumber used in farm structures.

Study Question:

1. What are the desirable and undesirable characteristics of lumber?
2. What should be considered when selecting wood for structures?
3. How is lumber measured?
4. What are the grades of lumber?
5. What wood preservatives are available?
6. What are the uses and types of plywood?

References:

1. Basic Carpentry, available through Reston Publishing Company, Inc., Reston, VA 22090 $15.95
2. Practical Farm Buildings, available through The Interstate Printers and Publishers, Inc., Danville, IL 61832 $7.95
3. Structures and Environment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $5.00

UNIT - CONSTRUCTING FARM BUILDINGS

TEACHING PROCEDURE

A. Review

B. Motivation: Bring in some examples of warped, knotted, or cracked boards and show the problems of workability of the board and the decrease in the strength of the boards.

C. Assignment: Check a farm structure at home for signs of defects.

D. Supervised Study: Have a contest to identify different defects in wood samples collected in the community.

E. Discussion

1. Wood is a very versatile and variable building material. Although its characteristics vary greatly in things such as species, moisture, and quality, the use of wood products in construction remains easy and economical.

   What are the desirable and undesirable characteristics of lumber?

   1) For farms with their own supply of lumber, it is common to see lumber used in all types of construction. Farmers have found the following desirable characteristics of wood.
      a) It is light weight.
      b) It can be purchased locally and in many easily handled sizes.
      c) It can be worked with simple tools.
      d) It is adaptable to many different uses.
      e) It is relatively inexpensive.
   2) Along with the desirable characteristics can be found several undesirable ones.
      a) It will decay.
      b) Some woods are dimensionally unstable and will change shape.
      c) Wood will burn.
      d) It cannot be easily cleaned and disinfected.
   3) Other characteristics to consider when selecting lumber include:

a) Hardness: The workability of the wood, i.e. driving nails, etc., must be considered.
b) Paint holding ability: Woods vary greatly on their ability to hold paint.
c) Nail holding power: The denser and harder woods hold better but split more easily.
d) Gluing characteristics: Hardwoods are harder to glue than softwoods.
e) Bending strength: Softwoods are best for flexibility.
f) Stiffness: Hardwoods are best for strength under a load.
g) Toughness: What lumber has the ability to absorb shock and impact?

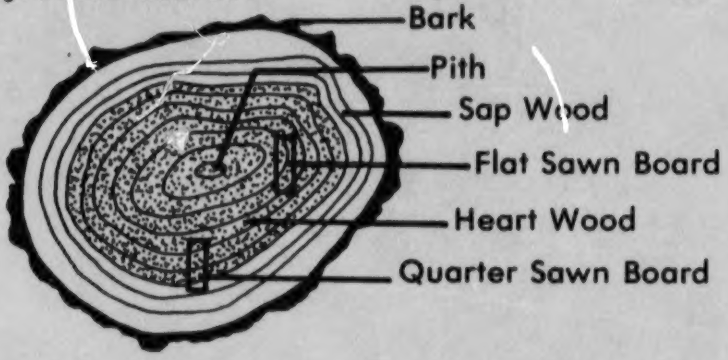
2. There are three main factors to consider when determining the wood for the job: (1) appearance, (2) durability, and (3) strength.

What should be considered when selecting wood for structures?

1) Appearance is considered when the board is used for trim or is visible within the structure. Millwork must be free of knots and a type of wood that will not warp or crack easily. Heartwood of trees is preferred for this type of work because of its resistance to decay and its color.
2) Durability is a factor on surfaces that will be subjected to the wear and tear of animals and machinery. Summer wood (wide ring) is more durable than winter wood; so select woods that are quarter-sawn, wood which has the edge of the growth rings exposed.
3) Strength is the most important consideration for farm applications. Heavy, supporting braces, poles, posts, and trusses need strength to perform their jobs. Watch for cross-graining, large knots, checks and cracks, and decayed sections that might weaken the wood.
4) Purchase wood that has been air dried or dried in a kiln. Using wood with over 19% moisture could lead to cracking, warping, and shrinking of the wood members.
5) The use of a wood will depend on the size and number of defects found in the wood. The following are examples:

a) Knots are where sections of the branches have been encased in the surrounding wood during growth.
b) Shakes are separations in the wood fibers parallel with the growth rings, which affect strength.
c) Check is the lengthwise separation of wood across the annual growth rings, caused by shrinkage.
d) Wane is a bark, or a lack of wood on the corner of a piece of wood from any cause.
e) Cross grain is when the grain is not parallel to board length.
f) Decay is disintegration of wood by fungi.
g) Warp is a variation from straightness in a piece of wood.
h) Stain is a discoloration of wood from natural color.

6) The wood used for lumber is cut into rectangular shapes from the log. The two panels cut are (1) quarter sawn and (2) flat sawn. Quarter sawn results in edge-grained wood; flat-sawn results in flat- or slash-grained boards.



Method of cutting board from a log.

3. To assure that you purchase enough lumber to construct the building, you must be able to calculate board feet.

How is lumber measured?

1) The unit of measure attributed to lumber is board foot. A board foot is a section of wood that measures 1 foot long by 1 foot wide by 1 inch thick. To calculate the board feet in a longer, wider, or thicker piece of lumber, the following formula is used:

Board feet = number of pieces X thickness in inches X width in inches X length in feet ÷ 12.

$$\text{Bd. Ft.} = \frac{\text{\# Boards X T X W X L}}{12}$$

If the length is in inches use this formula:

$$\text{Bd. Ft.} = \frac{\text{\# Boards X T X W X L}}{144}$$

Example: You have 5 pieces of wood 2 inches thick, 4 inches wide, and 8 feet long. How many board feet of wood do you have?

$$\frac{5 \text{ X } 2'' \text{ X } 4'' \text{ X } 8'}{12} = 26\ 2/3 \text{ Bd. Ft.}$$

2) If the plans call for the outer surface to be covered by boards, the actual area covered by one board is smaller than indicated because of surfacing (planing) loss. A correction factor needs to be added when ordering the covering material; it amounts to about 10% of the width.

For 6-inch boards, add 1/6 inch.
For 10-inch boards, add 1/10 inch.
For 12-inch boards, add 1/12 inch.

For an area of 600 inches this would mean:

a) If 6-inch boards are used, 100 boards X 1/6 inch = 17 inches needed or three additional boards.
b) If 10-inch boards are used, 60 boards X 1/10 inch = 6 inches. One additional board cut to 6 inches is needed.
c) If 12-inch boards are used, 50 boards X 1/12 inch = 4.15 inches. One additional board cut to fit is needed.

4. When purchasing lumber, how do you know what your're getting? The wood grading system is the answer.

What are the grades of lumber?

1) The identification procedure of lumber begins with classification. This classification is based on different widths and thicknesses and are as follows:

	Thickness	Width
Common Boards	1"	2" or more
Light Framing	2" to 4"	2" to 4"
Joists & Planks	2" to 4"	6" and wider
Beams & Strings	5" and thicker	More than 2" wider than thick
Posts & Timbers	5" x 5" and larger	Less than 2 " wider than thick

Lumber 2 inches thick and over is referred to as dimension lumber.

2) When the log is sawn at the mill, threa classes of lumber come from each log: (1) yard, (2) furniture or hardwoods, and (3) structural.

Yard lumber is common size and specie found in the local lumber yard that is used in construction.

Furniture or hardwood lumber is used in tables, chairs, and other millwork.

Structural lumber is large sections of lumber that have very few and very small defects, laminated sections, and planks.

3) Lumber is also graded according to its extent of manufacture.
   a) Rough lumber has not been dressed (surfaced) but has been sawed, edged, and trimmed at least to saw marks showing in the wood on the four longitudinal surfaces of each piece for its overall length.
   b) Dressed (surface) lumber has been planed to smooth surfaces and uniform size on one side (SIS), two sides (S2S), one edge (S1E), two edges (S2E), or combination of sides and edges (S1S1E, S1S2E, S2S1E, S4S).
   c) Worked lumber has been dressed and has been matched, shiplapped, or patterned.

d) Matched lumber has been worked to a tongue on one edge of each piece and a groove on the opposite edge for close tongue-and-groove joints by fitting two pieces together; when end-matched, the tongue and groove are also worked in the ends.

e) Shiplapped lumber has been worked or rabbeted on both edges of each piece for a close lapped joint by fitting two pieces together.

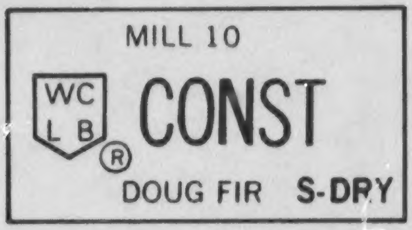
f) Patterned lumber is further worked to a pattern or molded form.

4) There are three regional associations that grade most of the softwood lumber: the Southern Pine Inspection Bureau (SPIB), the West Coast Lumber Inspection Bureau (WCLB), and the Western Wood Products Association (WWPA). The standards try to parallel the American Lumber Standard.

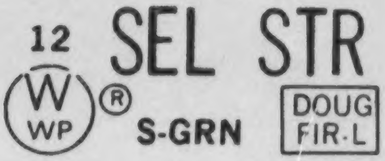
Typical grades of lumber used in farm construction are on the following page.

Classification	Grades	Description or Use
Dimension 2" to 5" thick 2" or more wide	**Structural Light Framing** (2"-4" thick, 2"-4" wide)	• For engineered use where higher strength is needed.
	Select Structural	• Use where high strength and stiffness and good appearance are needed.
	No. 1	• Use about the same as SEL STR, a little lower in quality.
	No. 2	• Recommended for most general construction uses.
	No. 3	• Use for general construction where appearance is not a factor.
	Light Framing (2"-4" thick, 2"-4" wide)	• Provides good appearance where high strength and high appearance are not needed.
	Construction	• Recommended and widely used for general framing purposes.
	Standard	• About same uses as CONSTRUCTION but a little lower in quality.
	Utility	• Used for studding, blocking, plates, etc. where economy and good strength are desired.
	Economy	• Suitable for crating, bracing and temporary construction.
	Studs (2"-4" thick, 2"-4" wide) Stud	• Only one grade; suitable for all stud uses.
	Structural Joists & Planks (2"-4" thick, 6" & wider)	• For engineering applications.
	Select Structural	• Use where high strength and stiffness and good appearance are needed.
	No. 1	• Use about same as SEL STR; a little lower quality.
	No. 2	• Recommended for most general construction use.
	No. 3	• For use in general construction where appearance is not a factor.
	Appearance Framing (2"-4" thick, 2" & wider) A	• Use exposed in housing and light construction for high strength and finest appearance.
Timbers 5" or more in least dimension	Select Structural	• Use where superior strength and good appearance are needed.
	No. 1	• Similar uses to SEL STR; a little lower in quality.
	No. 2	• Recommended for general construction.
	No. 3	• Use for rough general construction.
Boards up to 1½" thick, 2" or more wide		• Graded for suitability for use in construction.
	SEL MER or 1	• Use in housing and light construction for exposed paneling, shelving, etc.
	CONST 2	• Use for subfloors, roof sheathing, etc.
	STD 3	• Used about the same as #2 but a little lower in quality.
	UTIL 4	• Combines usefulness and low cost for general construction purposes.
	ECON 5	• Use for low grade sheathing, crating and bracing.
Finish or Selects up to 1½" thick, 2" or more wide		• Graded on basis of appearance.
	B & BTR	• Nearly clear with only minor defects; suitable for natural finish.
	C	• More and larger defects than B & BTR but suitable for paint finish.
	D	• A little lower in quality than C but still suitable for paint finish.

5) After grading, most yard and structural lumber is grade stamped to help the consumer identify a given piece's grade. In addition to the grade, the stamp normally indicates the grading association, the mill that manufactured the lumber, the species, and the moisture content at which the lumber was surfaced. The following are typical grade stamps of two different grading associations:



WCLB = the grading association.
MILL 10 = the mill code number.
CONST = the lumber grade.
DOUG FIR = the lumber species.
S-DRY = lumber surfaced at 19% mc or less.



S-GRN = lumber surfaced green.
DOUG FIR-L = the species is mixed Douglas Fir and larch.
WWP = the grading association.
12 = the mill code number.
SEL STR = the lumber grade.

5. For buildings that will be subjected to weathering from water, fungi, or other destructive forces, a form of protection is needed to extend the life of the structure.

What wood preservatives are available?

1) Most woods used on the farm are the type that will decay when exposed to damp conditions. Because of these problems, the use of wood preservatives has risen in farm structures.
   a) There are three basic classifications of preservatives: oil-borne, water-borne, and water-repellent.

2) Oil-borne preservatives are used for poles and wood which are in contact with the ground where conditions are ideal for termite and fungi attack or where wood is subjected to extreme conditions above ground. A permanent-type oil-borne preservative is recommended by government agencies and other impartial users of wood. Poles should be properly treated according to accepted specifications and should be branded with the treating company's name.

3) Creosote is a distillate of coal tar produced by high temperature carbonization of bituminous coal. It consists principally of hydrocarbons and contains considerable quantities of tar acids and tar bases. It is a mixture containing similar carbon compounds. Creosote will burn the skin, so care must be taken to protect hands and arms from coming in contact with the creosote.

4) Penta is a crystalline organic compound of a light brown color commercially available in flake form but put into the wood in solution after it is mixed with oil solvent. It is a scientific product--a single compound developed by research for the wood preservation industry. When ready to use, penta is normally dissolved in petroleum oil in predetermined proportions. Penta-in-oil readily penetrates wood surfaces and wood cells. The two raw materials from which penta is derived are coal tar and brine.

5) Water-borne preservatives, of which there are about 30, are used commercially. They are clean and effective, and surfaces treated with them are easily painted. The mark LP-22 means the treatment is suitable for below ground use, while the mark LP-2 is for use above ground only.

6) Water-repellent preservatives containing penta have been developed for the treatment of wood, including window sashes, doors, and other millwork in which a degree of water repellency is combined with resistance to decay and insects. These preservative solutions leave the wood clean and dry.

7) There are two methods--pressure and thermal--that are used extensively to treat lumber with preservatives.
   a) Pressure method involves a metal cylinder that is airtight. The wood is placed inside the cylinder; then the preservative is pumped in and forced into the wood at 200 psi. After treatment, excess preservative is removed by vaccuum.
   b) The thermal method immerses seasoned lumber for several hours in alternating baths of hot and cool preservatives. The hot bath expands the air in the outer layer of the timbers and evaporates the moisture. The cold bath causes the air and vapor remaining in the outer shell of the wood to contract, thus forming a partial vacuum. To satisfy this vacuum, atmospheric pressure tends to force the surrounding preservative into the wood.
   c) Creosote and oil-borne preservatives are recommended for outdoor use only due to their smell, leaching, and high life expectancy.

6. Plywood is used for subfloors, walls, temporary ceilings and many other uses because of its versatility in the building industry.

What are the uses and types of plywood?

1) Plywood consists of layers of veneer of any thickness up to 1/4 of an inch cross-banded and glued. The number of layers or plies is always odd--3, 5, 7, and so on. The grain direction of the alternate layers is laid at right angles.

2) The core of the plywood may vary according to its usage. Veneer core uses layers the same size. Lumber core uses basswood or poplar for extra strength, particle board to reduce cost, and moncor for insulation improvement.

3) One of the two types of plywood is the interior type. Interior type has a lower level of moisture resistance and lacks the durability of exterior grade.
4) Exterior type plywood is used where the wood will be exposed continuously or repeatedly to moisture levels above 18%.
5) Plywood grades are based on engineered or appearance standards.
   a) Appearance grades are designated by the panel thickness, by the classification of face and back veneers, and by the species group of the veneers.
   b) "Engineered grades" are largely the unsanded sheathing panels designated C-D Interior or C-C Exterior. Either of these grades may be modified by the terms STRUCTURAL I or II. Use structural grades where strength is important. "Identification Index" measures plywood stiffness and strength parallel to the face grain. It consists of two numbers separated by a slash mark. The number on the left is the maximum spacing for roof supports under 38 psi live load. The number to the right of the slash is the maximum spacing for floor supports under residential loading of at least a 160 psi concentrated load.
6) N and A are the highest grade levels. There are no knots. Use N for natural finish. B is for a solid surface such as that used in concrete forms. C is the lowest grade allowed for exterior type. It has small knots and is used for sheathing. C plugged is an improved C used in underlayment. D has large knots but is used for backing for interior panels.

F. Summary

Be sure to inspect lumber before purchasing it to be sure of the quality of the material for each job. Board feet is the measurement of the building industry. Learn how to use it. Use treated wood in buildings that will be subjected to weathering. Plywood is a multi-purpose material but its use must be planned carefully to be sure the job is done correctly.

G. Evaluation

Answers to Exam

1. Practical evaluation of quiz is to be determined by instructor.
2. Answer is to be determined according to instructor's specifications.
3. a. 40 board feet
   b. 25 1/3 board feet
   c. 26 2/3 board feet
4. a. Oil-borne - soak
   b. Creosote - pressure treated, heat and pressure treatment
   c. Penta - pressure treated
   d. Water-borne - soak, brush applied
   e. Water-repellent - soak, brush applied
5. Appearance grades are designated by the panel thickness.
6. Engineered grades are based on the unsanded sheathing panels designated C-D Interior or C-C Exterior.
7. a. Interior
   b. Exterior

139

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 13 - How is building lumber made and selected for use in farm structures?

EXAM

1. Set up a defect identification quiz.

2. Calculate the board feet in a board.

3. Calculate problems for board feet.

   a. 6 pieces 1" x 8" x 10'

   b. 8 pieces 2" x 6" x 38"

   c. 5 pieces 2" x 4" x 8'

4. List the preservatives and the methods for applying them.

   a.

   b.

   c.

   d.

   e.

5. Define appearance grades.

6. Define engineered grades.

7. What are the 2 types of plywood?

   a.

   b.

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 14 - What are the planning and design factors of beef housing and equipment?

Objective: Upon the conclusion of the lesson, students will be able to (1) plan cattle feeding facilities; (2) plan the manure facilities; (3) plan basic design factors; and (4) apply design factors of feeding and handling equipment.

Study Questions:

1. What are the types of beef systems?
2. Which factors must be determined before facilities planning can begin?
3. How do you plan cattle feeding facilities?
4. How do you plan cow-calf facilities?
5. How are the manure handling facilities planned?
6. How do you plan the ventilation of cattle structures?
7. It is necessary to plan for what utilities in cattle facilities?
8. What factors affect the planning of animal handling facilities?
9. How do you design feed storage, processing, and handling facilities for beef?
10. What materials are used to construct beef facilities and equipment?

References:

1. Beef Housing and Equipment Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50
2. Transparencies:
    a. TM-1: Cattle Flow
    b. TM-2: Processing and Mixing
    c. Vis-6: Visual Aid Masters for MWPS #6 $4.00

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 14 - What are the planning and design factors of beef housing and equipment?

TEACHING PROCEDURE

A. Review basic design factors.

B. Motivation: How many students have beef cattle operations? Is it easy to move the livestock from one point to another? Could time be saved by replanning facilities?

C. Assignment: Draw the layout of a local beef farm on paper and have the students evaluate the layout for efficiency.

D. Supervised Study: Conduct a field trip to a local beef farm and check the layout for time factors and adequacy of space.

E. Discussion

1. It is seldom that two beef operations will be the same in arrangement, but each will have one or more of the components listed in this section.

   What are the types of beef systems?

   1) Barn and feed lot
   2) Feeding barn and lot
   3) Open feed lot
   4) Cold confinement barn
   5) Warm confinement barn

2. Before the first building can be planned in the layout, decisions must be made on factors that will determine the number of cattle and environmental factors.

   Which factors must be determined before facilities planning can begin?

   1) Determine number of cattle.
   2) Determine type of facilities.
   3) Determine location of facilities.
      a) Dust
      b) Runoff
      c) Waste
      d) Roads
   4) Compute requirements. (Page 4 of text)
   5) Select structures and layout.

3. Many factors go into the planning of the actual facilities for feeding beef cattle. Feed lots are becoming more and more common with the costs of land and fuel rising steadily. On the board, sketch in each part of the facility as it is discussed by the class.

   How do you plan cattle feeding facilities?

   1) Cattle space requirements are planned in square feet per head of cattle. (See chart on pages 4 and 6 of the reference.)
   2) Are the alley traffic routes wide enough for feeding equipment?
   3) What part of lot should be paved?
   4) Mounds and drainage factors must be considered. (See diagram on page 7 of your text.)
   5) Topography and Drainage
      a) Slope, 4% to 6%
      b) Drainageways
      c) Feedbunks
   6) Shading
   7) Convenient feed facilities
   8) The systems used (See pages 8 to 13 of your text.)
      a) Barn and feed lot
      b) Feeding barn and lot
      c) Open feed lot system
      d) Cold confinement barn
   9) Large cattle facilities may need special features.
      a) Special service area
      b) Special features in working facilities
      c) Separate conditioning lots
      d) Hospital facilities

4. The only time buildings are needed for the cow-calf operator is during calving or for helping sick animals.

   How do you plan cow-calf facilities?

   1) Gestation requires only a wind break.
   2) Building is needed on extremely cold days for first few days following parturition.
   3) Calf shelters are required for a dry place to lie down.
   4) Open facilities are recommended to prevent spread of air-borne disease.
   5) Plan for accessibility.

5. The main concerns of manure are controlling the runoff and odors produced when manure accumulates. Draw on the board and have the students complete a runoff plan for a beef operation in your area.

   How are the manure handling facilities planned?

   1) Utilize manure with no pollution.
   2) Control the solid waste.
   3) Control the lot runoff with screens and holding ponds.
   4) Use MWPS-18 Livestock Waste Facilities Handbook for design criteria.
   5) Select confinement systems.
      a) Pits
      b) Flushing
   6) Select method of application of manure to the land.
   7) Control odor.

6. If complete buildings are used in the farm plan, ventilation must be considered carefully in the planning stages to prevent a build-up of moisture and odors.

   How do you plan the ventilation of cattle structures?

   1) Ventilation is a continuous process.
      a) It removes moisture.
      b) It provides fresh air.
      c) It removes excess heat.
      d) It removes odor and gases.
   2) Cold house ventilation should be planned.
   3) Windbreak planning is necessary.
   4) Snow fencing is desirable.

7. List the utilities on the board and have the class discuss the necessities of each in cattle facilities planning.

   It is necessary to plan for what utilities in cattle facilities?

   1) Lighting can be used to increase eating time and provide security.
   2) Power supply must be sufficient to run all feeding equipment plus accessory items.
   3) Water supply should be plentiful to meet all needs.
   4) Use Ground Fault Interruptors for lightning protection for all buildings and wiring.

a) Protect from mass kills by removing isolated trees or protecting them.
b) Ground fences.

8. The location of fences, loading chutes, cutting gates, and other handling facilities need to be carefully laid out to facilitate a steady flow without stress to the animals. Draw several of the plans on the board and discuss the flow systems of each.

What factors affect the planning of animal handling facilities?

1) It must be convenient.
2) Minimum of labor required affects the planning.
3) Facilities must be safe for workers.
4) Animals can be kept under control by planning of correct facilities.
5) Working facilities (treating and loading) must be efficient.
6) Cattle flow should be controlled and smooth. TM-1 (See Figure 23 on page 29 of text.)
7) A complete facility provides these functions:
    a) Gathering
    b) Directed flow
    c) Holding
    d) Sorting
    e) Positioning
    f) Restraining
    g) Elevating or lowering
8) Plan corral.

9. In the facilities plan there must be space allocation for the feed storage handling and processing equipment. It must be convenient and well planned to promote efficiency. Feed handling is a daily job that is labor-intensive.

How do you design feed storage, processing, and handling facilities for beef?

1) Advance plan for 3 to 5 years; then double plan.
2) Consider storage for grains and roughages, processing methods, and distribution systems. Plan alternative system layouts.

3) Types of silos
    a) Gas-tight
    b) Conventional
    c) Corn, grass silages, haylages, high moisture grain
4) Silage moisture
5) High moisture grain silage
6) Safety with silos and silage
    a) Fire
    b) Gas
    c) Unloaders
    d) Chutes
7) Processing and Mixing
TM-2 (See Figures 33 to 38 of text.)
8) Silo storage and distribution systems
9) Hay storage and distribution systems

10. The construction materials used are outlined on pages 80 to 83 of the reference.

What materials are used to construct beef facilities and equipment?

1) Wood preservatives
2) Plywood of exterior and interior grades
3) Paint primer
4) Stains
5) Masonry mortar mixes
6) Concrete
    a) Construction layout
    b) Curing
    c) Floor thickness
    d) Cold weather work
    e) Hot weather work
7) Galvanized sheet metal
8) Fasteners
    a) Nails
    b) Screws
    c) Glue

F. Summary

When planning the beef facilities, you must pay particular attention to pollution factors, ease of movement of both livestock and facilities, and the type of livestock to be housed on the farm. Design will depend on the type of operation, the method of waste handling, availability of utilities, and environmental controls.

G. Evaluation

Answers to Exam

1. T
2. F
3. T
4. F
5. F
6. F
7. Any three of the following:
    a. Barn and feed lot
    b. Feeding barn and lot
    c. Open feed lot
    d. Cold confinement barn
    e. Warm confinement barn
8. Any three of the following:
    a. Moisture
    b. Heat
    c. Odors
    d. Gases
9. Any four of the following:
    a. Gathering
    b. Directing flow
    c. Holding
    d. Sorting
    e. Positioning
    f. Restraining
    g. Elevating or lowering
10. Any four of the following:
    a. Storage methods
    b. Processing
    c. Distribution
    d. Alternate layout
    e. Locating facility

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 14 - What are the planning and design factors of beef housing and equipment?

EXAM

T F 1. When deciding on the location of facilities, dust and odor are a major concern.

T F 2. Runoff is controlling the flow of water running off the roof.

T F 3. A topographic map provides help in building layout.

T F 4. Slope in a feed lot should be inward to better control runoff.

T F 5. The cow-calf operator should provide shelter year-round for her/his herd.

T F 6. It is illegal to spread beef manure before it is treated.

7. Name three types of beef systems.

   a.

   b.

   c.

8. What three things does proper ventilation remove from a structure?

   a.

   b.

   c.

9. A complete cattle handling facility provides an organized system for these functions.

   a.

   b.

   c.

   d.

10. To develop a feed storage and handling system plan, consider:

a.

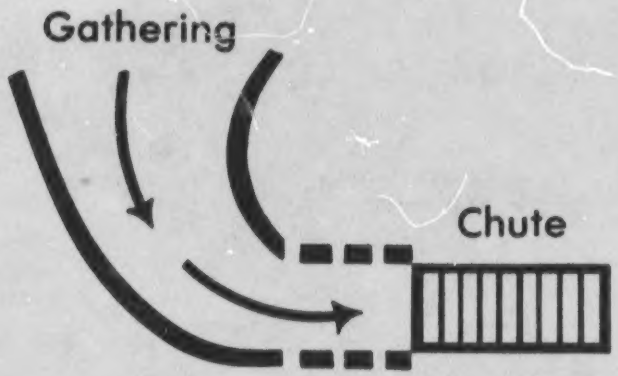
b.

c.

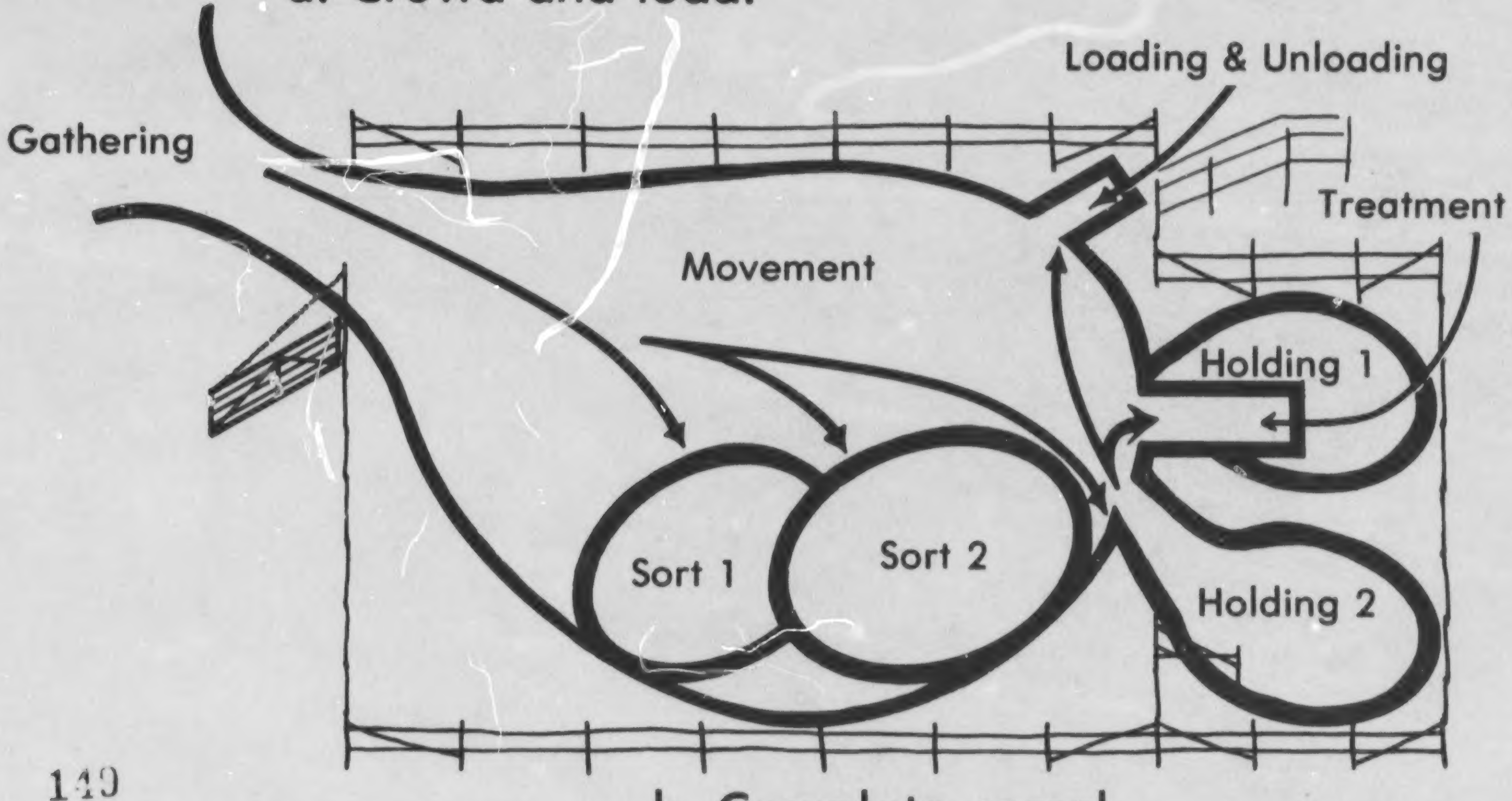
d.

148-A

Cattle Flow


Gathering
Chute

a. Crowd and load.

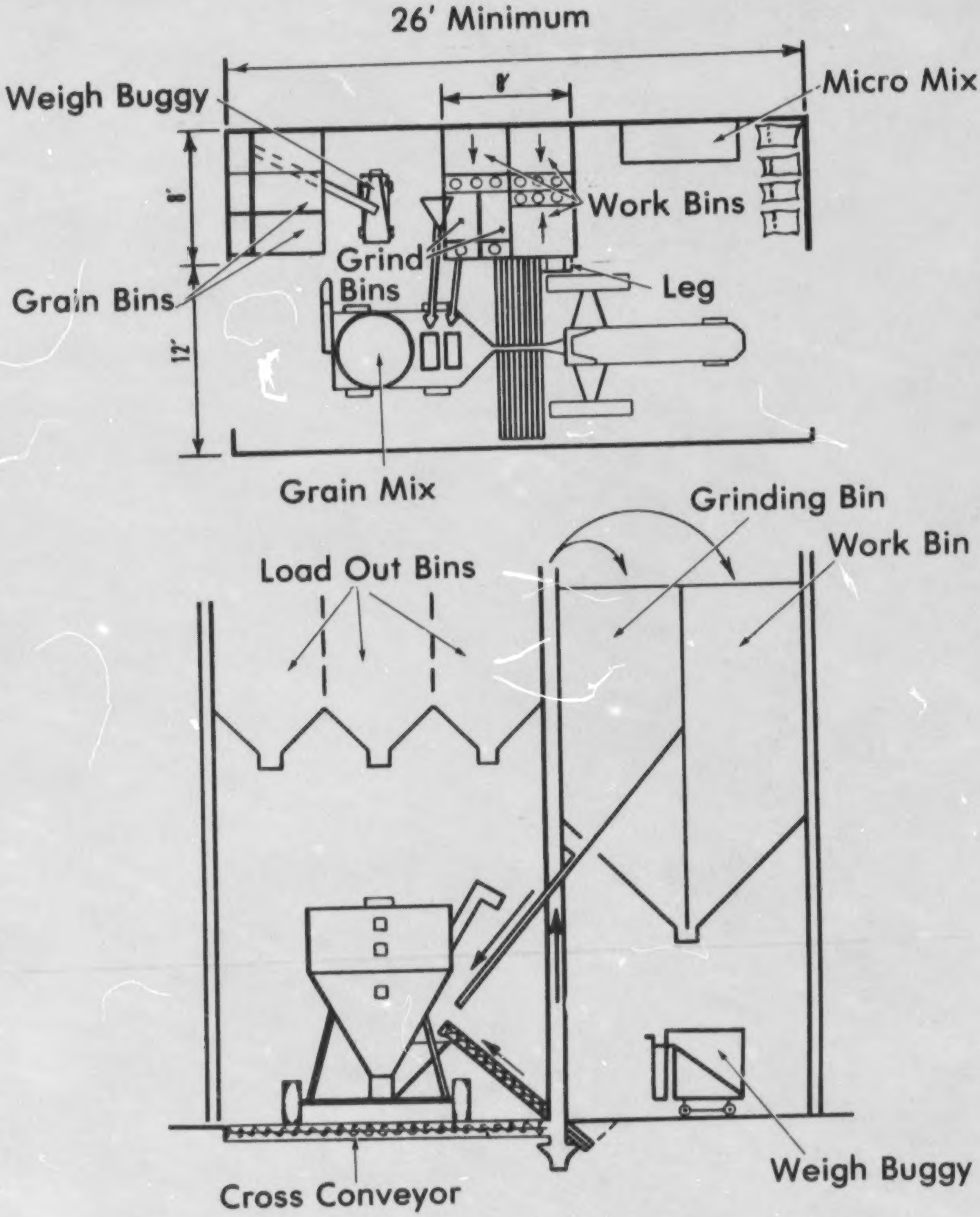

Loading & Unloading
Gathering
Treatment
Movement
Holding 1
Sort 1
Sort 2
Holding 2

b. Complete corral.

TM-1

TM-2

Processing and Mixing


26' Minimum
8'
Weigh Buggy
Micro Mix
8'
Work Bins
Grind Bins
Grain Bins
Leg
12'
Grain Mix
Grinding Bin
Work Bin
Load Out Bins
Weigh Buggy
Cross Conveyor

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 15 - How is a pole or post building constructed?

Objective: Upon the conclusion of the lesson, students will be able to identify the types and designs of pole buildings and to identify their methods of construction.

Study Questions:

1. What are the advantages and limitations of pole buildings?
2. What are the terms used for parts of pole and post buildings?
3. What are the site and drainage requirements of pole buildings?
4. What types of materials are used in pole building construction?
5. Which design factors are important for pole construction?
6. How are framing members selected?
7. How are pole buildings braced to add strength?
8. What are the wood fasteners used?
9. How are suspended floors designed and framed?
10. What special considerations are needed for grain storage pole structures?
11. What are the construction procedures for a pole building?

References:

1. Pole and Post Building Construction, by NRAES, available from Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $1.50
2. Transparencies:
   a. TM-1: Post Building with Trusses
   b. TM-2: Pole Building with Common Rafters
   c. TM-3: Building Layout
   d. TM-4: Aligning and Bracing Poles

Lesson 15 - How is a pole or post building constructed?

TEACHING PROCEDURE

A. Review woods and foundations.

B. Motivation: How many students have pole or post buildings on their farms? How many have seen or helped to construct one?

C. Assignment

D. Supervised Study

E. Discussion

1. List the advantages and limitations of a pole or post building on the board and ask the students to give an example of each type of building. Discuss these factors in relation to other types of construction.

   What are the advantages and limitations of pole buildings?

   Advantages

   1) Easiest to build
   2) Least cost
   3) No large foundation
   4) Minimal site preparation
   5) Can be built in units and expanded
   6) Poles and posts support roof, freeing walls.
   7) Bracing allows for more open area.

   Limitations

   1) Rocky ground limits pole setting depth.
   2) Pole buildings have height limits.
   3) Limit heights to 20 feet and spans to 60 feet.

2. In order to teach a unit without student confusion, the terms must be consistent throughout the unit. Use TM-1 for post building terms and TM-2 for pole building terms.

   What are the terms used for parts of pole and post buildings?

Post

1) Grade
2) Post span
3) Footing pad
4) Bottom chord bracing
5) P.P.T. post
6) Post to truss brace
7) Roof truss
8) Purlin
9) Ridge
10) Roofing
11) Eave
12) Post spacing
13) Tie down block
14) Spaced girder

Pole

1) Includes from post steps 1, 3, 5, 8, 9, 10, 11, 14.
2) Pole to girder brace
3) Rafter
4) Braces
5) Rafter span
6) Siding
7) Girt
8) P.P.T. skirt planking

3. The location of the building will be determined in the total farm plan. Planning for basic drainage is important because of runoff controls.

   What are the site and drainage requirements of pole buildings?

   1) Site should provide wind protection for animals.
   2) Site should protect the building from weather damage.
   3) For fire safety, space poles 50 to 75 feet apart.
   4) Slope for drainage should be 2% to over 5% for inside animal problems. Drainage slopes should be 3% to 5% on an outside structure away from the building.
   5) Use terraces to direct surface drainage to a place 50 feet away.
   6) Seepage should be controlled with interceptor trench protected from heavy equipment.

4. Brainstorm with the students about different materials needed in construction. List these materials on the board. Discuss the characteristics and types of each.

What types of materials are used in pole building construction?

1) Poles or posts
    a) Pressure treated with creosote, pentachlorophenol, or water-borne salt
2) Lumber species, size, and grades
3) Roof Trusses--Single Slope, Scissors, Fink, Howe, Belgian, Bowstring
4) Roofing and Siding--metal sheets, galvanizing, alloys, fasteners, wood products, and asphalt
5) Roof drainage
6) Door sizes and types--rolling, sliding, and overhead
7) Skylights and windows--fiberglass and reinforced plastic

5. Critical load factors can collapse a building if they are not planned ahead when designing a farm structure. The examples given in the reference deal with the Northeast but can be made applicable with loads found in the Structures and Environment Handbook by MWPS.

Which design factors are important for pole construction?

1) Wind loads--use MWPS
2) Snow loads--Missouri is in Zone I for design loads of 12 psf.
3) Pole and post design--size and spacing of poles and post is a design factor.
4) Footings (Work example on page 12 of text.)
5) Embedment (Watch the frost line.)
6) Casings of concrete or soil/cement with tying
7) Backfill is based on soil type.

6. When calculation of all of the loads on a building is done, the calculated load is used to determine the size of the framing members.

How are framing members selected?

1) Find load per foot of rafter and load per foot of girder.
2) Correct for snow and wind loads.
3) Use the Table on page 15 of text to find sizes.

7. Draw the different bracing systems for pole or post structures on the board and discuss the stress protection that they offer.

How are pole buildings braced to add strength?

1) Wall braces
    a) Post to girder braces
    b) Post to truss or rafter braces
2) Roof bracing
    a) Diagonal bracing
    b) Web bracing
    c) Bottom chord bracing

8. Fasteners were covered in detail in an earlier lesson. But as a review, use the following outline.

What are the wood fasteners used?

1) Nails
    a) To the pole, 20d to 40d
    b) Framing members, 10d to 12d
    c) Purlins, 60d
2) Load capacity determines nail type.
3) Space nails to avoid splitting.
4) Clinching nails will improve strength.
5) Toe nail wood at perpendiculars.
6) Bolts need predrilling and washers.
7) Split for added strength.
8) Lag screws
9) Framing anchors simplify connections.
10) Glue
    a) Resorcinol resin
    b) Casein
11) Gluing procedure

9. For dry storage of equipment, tools, or feed, it is sometimes necessary to put a floor in the pole structure. Care must be taken to design the structure for sufficient strength to handle the needs.

How are suspended floors designed and framed?

1) Use Tables XII and XIII to estimate live and dead weight loads.
2) Determine the girder size, using Table XVI in your text for floor joists and Table IX for roof and floor.
3) Provide proper bracing. (See Figure 4 of your text.)

4) Work the example on page 22 of text to cover all the points for installing suspended floor.

10. Grain storage pole structures are inexpensive to construct and, if properly built, can provide long term storage.

What special considerations are needed for grain storage pole structures?

1) Stress in the structure is horizontal.
2) Tie tops of poles together to prevent roof damage. (Use wire cable.)
3) Stress is cubic. Increasing depth 10% increases stress 33%.
3) Read the Tables XVII and XVIII of your text to determine circumference, diameter, spacings, and depth of poles.

11. Once the designing of the facility is completed with all the loads calculated and the corresponding strengths studied, the construction can begin. In study questions 4, 5, 6, 7, 8, 9, and 10, the sizes of poles, bracing methods, girder sizes, and attaching methods were determined, so in this study question they are all combined to form a building.

What are the construction procedures for a pole building?

1) Layout and excavation (TM-3)
    a) Select site.
    b) Grade site.
    c) Batter board layout (Appendix A).
    d) Mark pole placement.
    e) Bore or dig pole holes.
2) Placing concrete pads
    a) Dig holes.
    b) Pour and cure (1 day).
3) Setting poles or posts (TM-4)
    a) Select four straight corner poles.
    b) Place poles in holes.
    c) Plumb two outside edges.
    d) Brace poles.
    e) Center and plumb outside edges of poles and tamp earth to 1/3 depth.
    f) Mark grade level.
4) Installing girders
    a) Measure and mark desired height.
    b) Nail support blocks to pole.
    c) Cut girders.
    d) Build double girders. (See Figure 8 on page 27 of text.)

        - e) Place girders on blocks and nail.
    - 5) Bracing and alignment
        - a) Install girder to pole bracing.
        - b) Check alignment.
        - c) Remove string line. Fill and tamp holes.
    - 6) Roof framing and bracing
        - a) Check trusses or rafters for width.
        - b) Place trusses or rafters on girders.
        - c) Check width and fasten to pole.
        - d) Fasten roof purlins.
        - e) Nail wind bracing.
        - f) Nail lower chord stiffeners (trusses).
    - 7) Roofing
        - a) Start roofing at lower corner.
        - b) Check for squareness.
    - 8) Siding and finishing
        - a) Remove temporary bracing.
        - b) Install knee bracing.
        - c) Install girts.
        - d) Install skirts, windows, doors, and siding.
        - e) Install trim.
        - f) Clean and finish grade.

F. Summary

Pole and post buildings are very popular because of their low cost and ease of construction. The structure can be built at almost any location on the farm and can be designed for several functions, such as grain and livestock handling. The pole buildings can be constructed using semi-skilled labor because it can be built with locally available material.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. T
5. T
6. Any three of the following:
    - a. Nails
    - b. Bolts
    - c. Split ring
    - d. Lag screws
    - e. Glue
    - f. Framing anchors
7. Any four of the following:
    - a. Easiest to build
    - b. Least cost
    - c. No large foundation

153

  d. Minimal site preparation
  e. Can be built in units and expanded
  f. Poles and posts support roof, freeing walls.
  g. Bracing allows for more open area.

8. See TM-3: Building Layout

UNIT - CONSTRUCTING FARM BUILDINGS

Lesson 15 - How is a pole or post building constructed?

EXAM

T F 1. P.P.T. stands for pressure preservative treatment.

T F 2. Livestock have difficulty standing in a building if the slope is over 5%.

T F 3. An interceptor trench is used to collect manure from a farm structure.

T F 4. Pentachlorophenol is an approved method of preserving poles.

T F 5. When determining the depth to set a pole, the builder must consider the depth of the frost line.

6. List three different fasteners used in farm buildings.

    a.

    b.

    c.

7. As we discussed in the lesson, list four advantages to a pole or post structure.

    a.

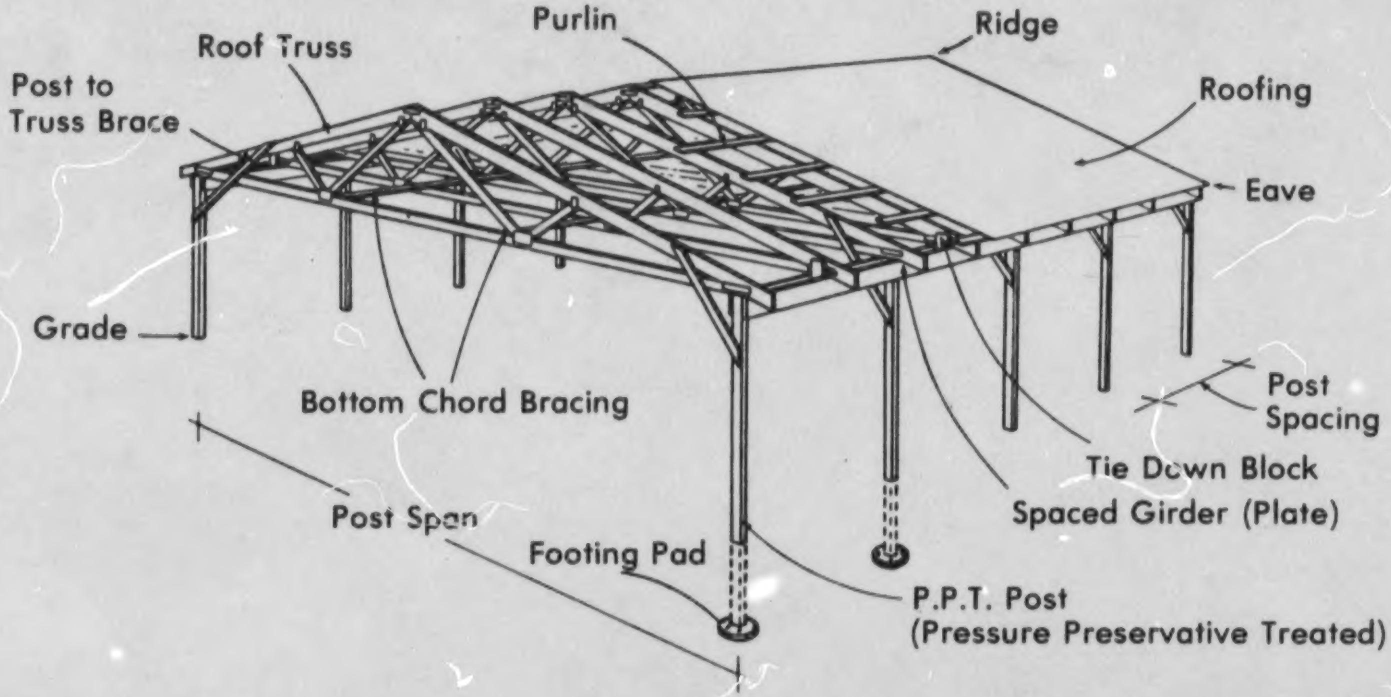
    b.

    c.

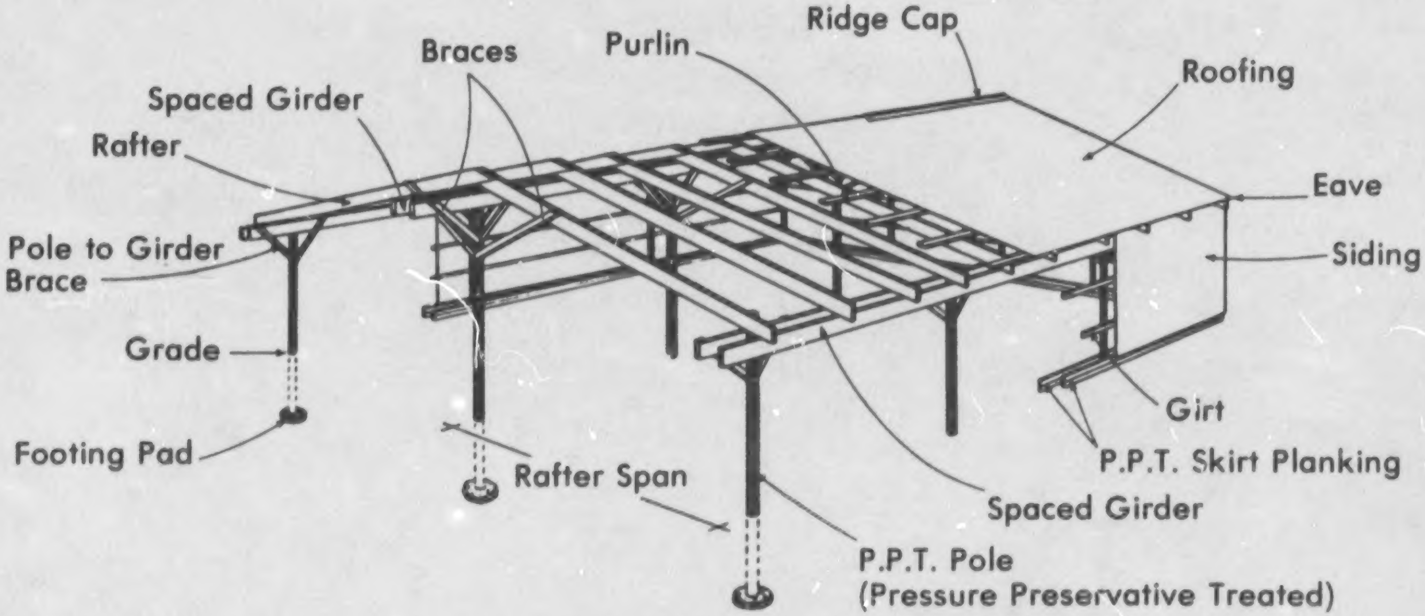
    d.

8. Describe the procedure for laying out a building using batter boards and a level.

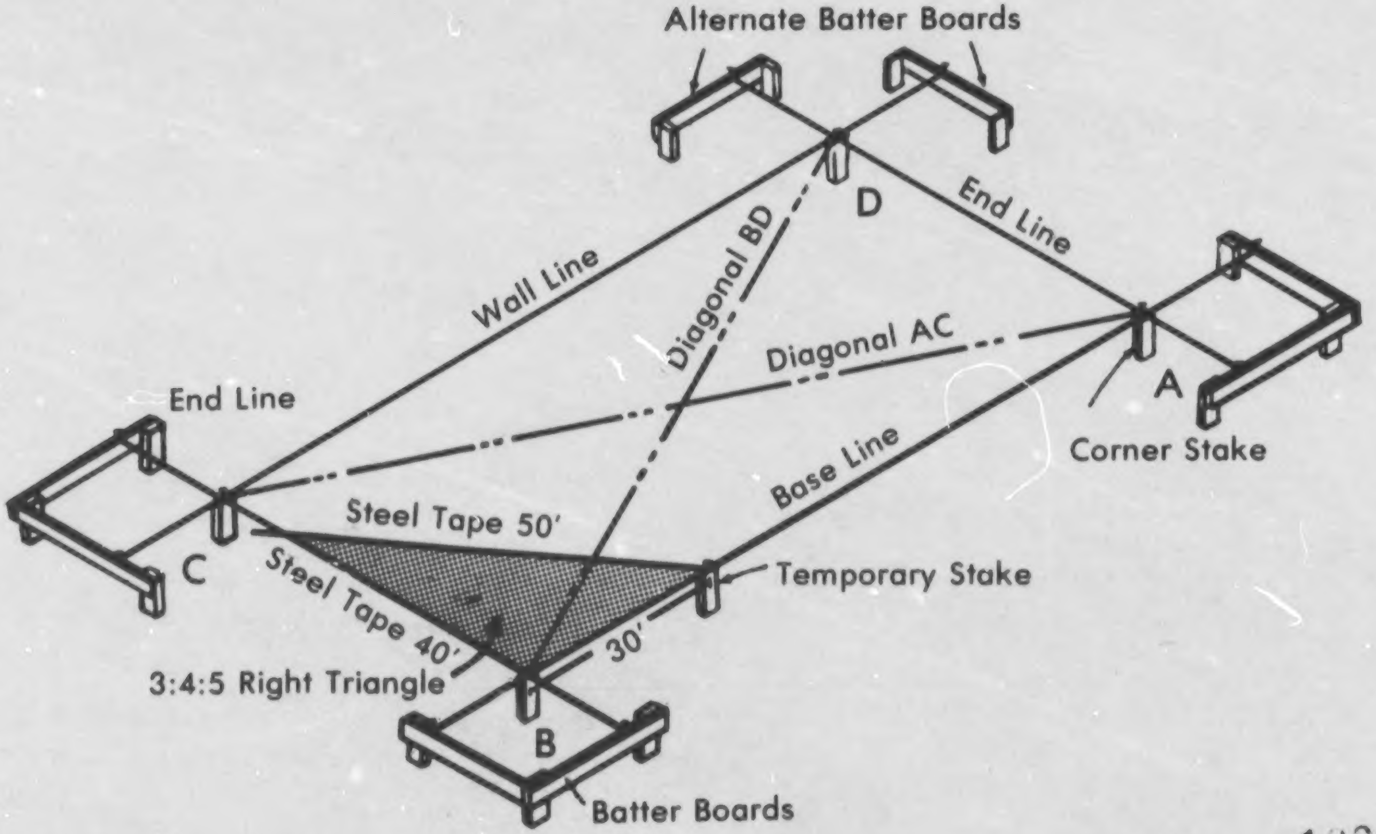
Post Building with Trusses


Purlin
Ridge
Roof Truss
Post to Truss Brace
Roofing
Eave
Grade
Post Spacing
Bottom Chord Bracing
Tie Down Block
Post Span
Spaced Girder (Plate)
Footing Pad
P.P.T. Post (Pressure Preservative Treated)

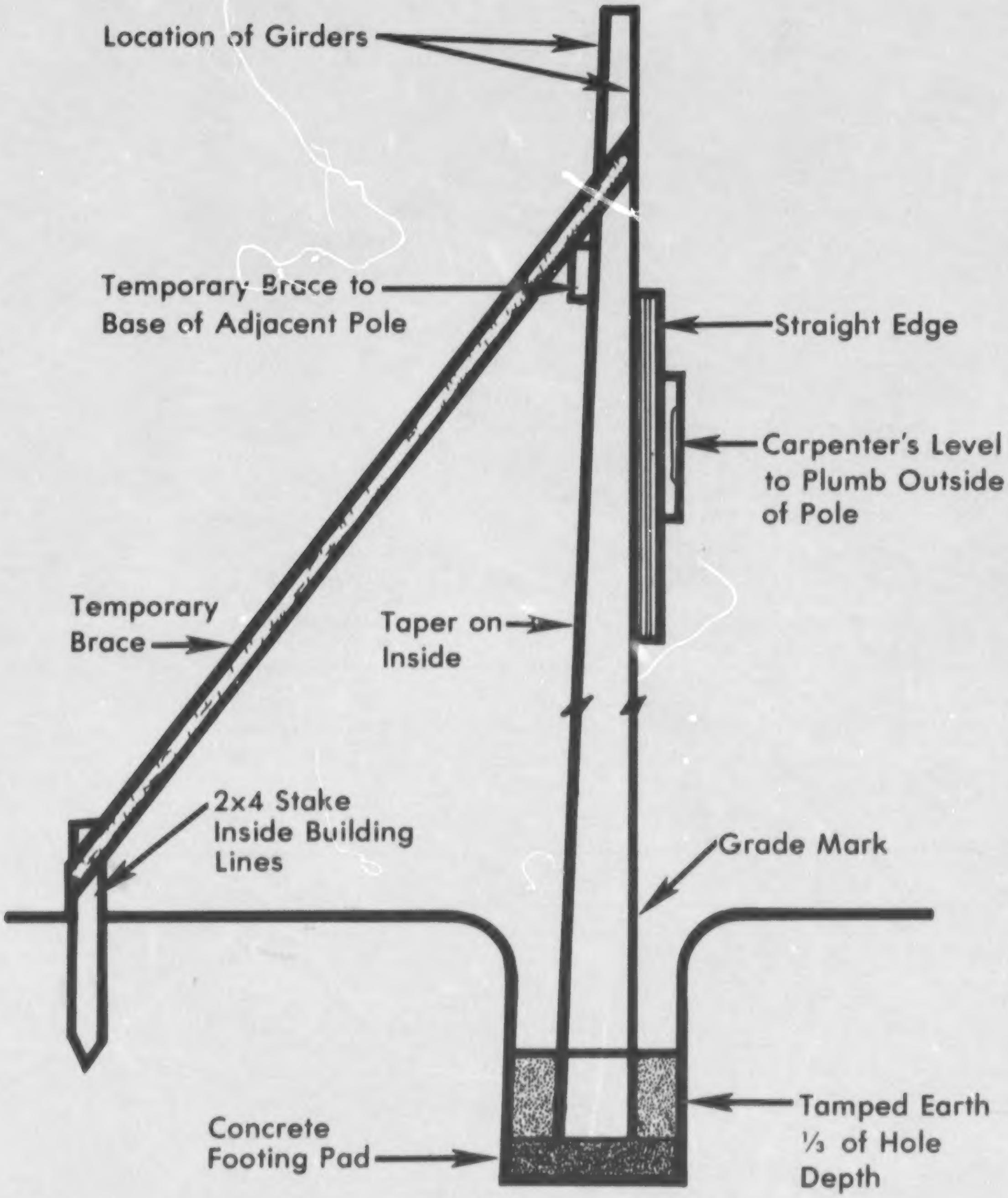
Pole Building with Common Rafters


Ridge Cap
Braces
Purlin
Roofing
Spaced Girder
Rafter
Eave
Siding
Pole to Girder Brace
Grade
Footing Pad
Rafter Span
Girt
P.P.T. Skirt Planking
Spaced Girder
P.P.T. Pole
(Pressure Preservative Treated)

Building Layout


Alternate Batter Boards
D
End Line
Wall Line
Diagonal BD
Diagonal AC
A
Corner Stake
End Line
Base Line
C
Steel Tape 50'
Temporary Stake
Steel Tape 40'
30'
3:4:5 Right Triangle
B
Batter Boards

Aligning and Bracing Poles


Location of Girders
Temporary Brace to Base of Adjacent Pole
Straight Edge
Carpenter's Level to Plumb Outside of Pole
Temporary Brace
Taper on Inside
2x4 Stake Inside Building Lines
Grade Mark
Tamped Earth ⅓ of Hole Depth
Concrete Footing Pad

UNIT - CONSTRUCTING FARM BUILDINGS

LABORATORY EXERCISE

Objective: Upon the conclusion of the laboratory exercise, students will be able to identify the parts of a rafter and to cut a rafter according to specifications.

Tools Needed:

1. Carpenter's square
2. Hand or power saw
3. Plumb line
4. Six-foot rule

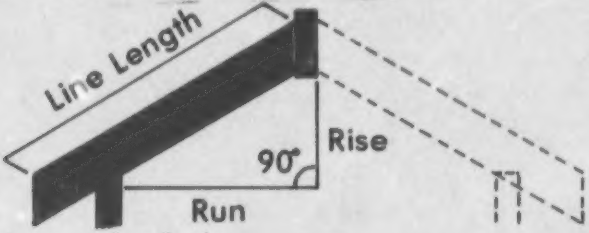
Materials Needed:

1. Two-inch by 4-inch by 8-foot board

Procedure:

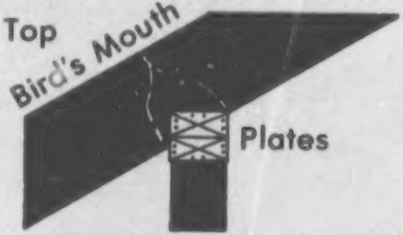
PART 1: IDENTIFY THE PARTS OF A RAFTER

Step 1: The line length of the rafter is determined by: $LL^2 = Rise^2 + Run^2$. This can be read from the rafter table on the carpenter's square.

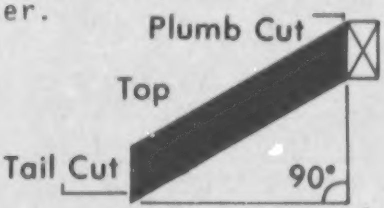


Step 2: Other terms include:

a) Bird's mouth is the notch made to fit the plate of the wall or support.



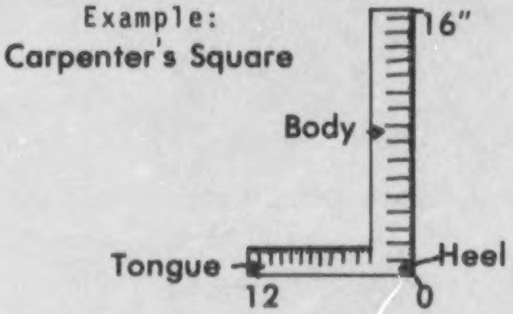
b) Plumb cut is a cut made on the rafter at the ridge board. Tail cut is a cut made on the lower end of the rafter.



c) Roof pitch is the slope of the rafter and can be determined with the carpenter's square and rafter table.

Step 3: Problem: Find the pitch and length per foot of run.
Needed: Carpenter's square
Rafter table

Example:



Rise = 16 inches.
Pitch (from rafter table) = 53°, 8 foot or 2/3 inches.
Length per foot of run = 20 inches.

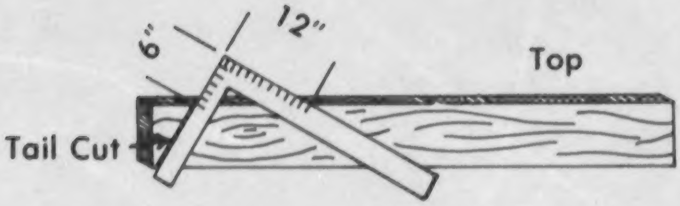
a) Rise = 12 inches. Answer: PITCH _____ LFR _____
b) Rise = 9 inches. Answer: PITCH _____ LFR _____

PART 2: CUTTING A COMMON RAFTER (STEPPING METHOD)

Step 1: Approximate the rafter length using the rafter table.
Rise = 6 inches, 1/4 pitch.
Run = 6 feet.
Length of run per foot = 13.42.
Approximate length minus overhang = 6 feet of run x 13.42 inches of length = 80.52 inches of line length.

Step 2: Add in overhang of 6 to 8 inches. We will use 6 inches. Length of board is now 86.52 inches. Rafter lengths are in 8-foot boards so use a 2-inch x 4-inch x 8-foot board.

Step 3: Make the tail cut using the carpenter's square to set the angle. The short part or tongue will be 6 inches and the long part or body will be 12 inches. Make the mark about 1/4 inch from the end.


6"
12"
Top
Tail Cut

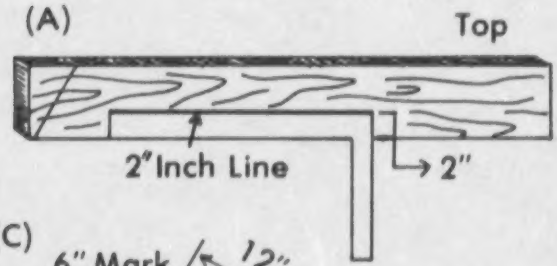
Step 4: The next step is to allow for the overhang and mark the bird's mouth for cutting.

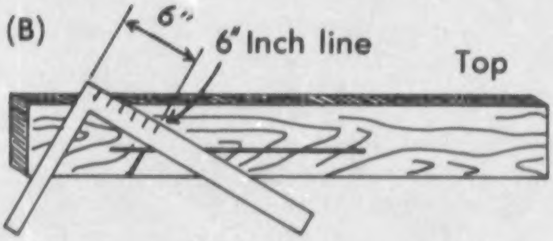
a) This is done by making a mark at the 2-inch mark of the board lengthwise, using the square as a guide.

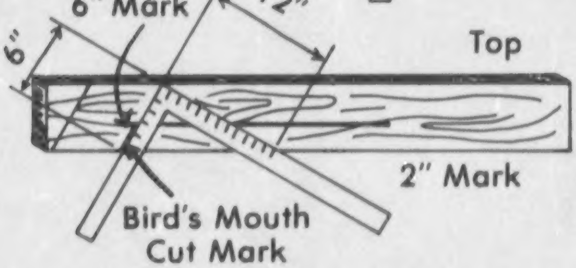
b) Lay the tongue end back on the tail cut line and move to the 6-inch mark on the body. Make a mark on the wood. (This is the bird's mouth cutting angle.)

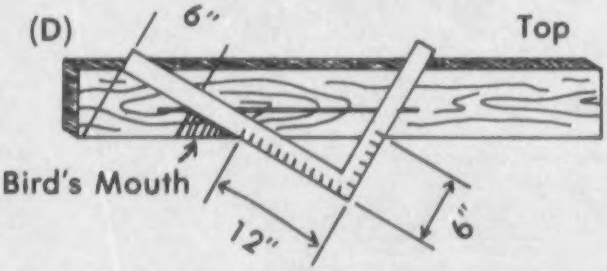
c) Next position the square with the heel flush with the outer edge of the board and body measuring 12 inches and the tongue measuring 6 inches. Then draw a line from the mark made at 2 inches to the edge of the board.

d) Move the square to the position found in D and mark the angle from the 2-inch line drawn in A.

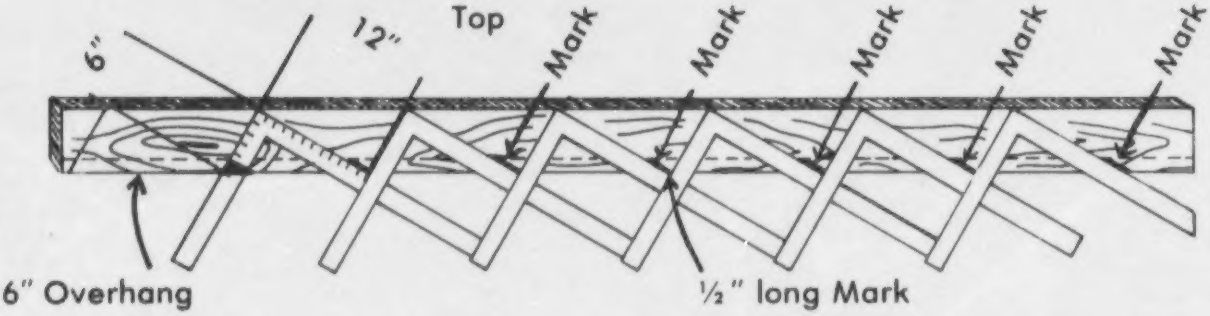

(A)
Top
2" Inch Line
2"


(B)
6"
6" Inch line
Top

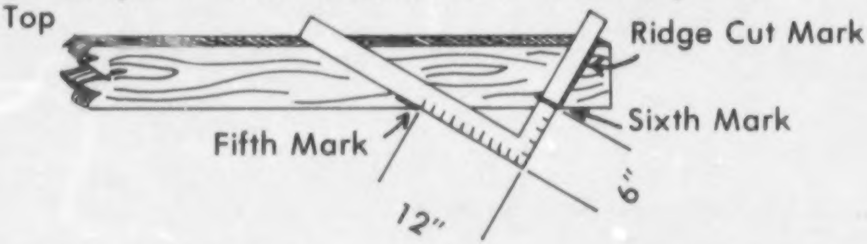

(C)
6" Mark
12"
6"
Top
2" Mark
Bird's Mouth
Cut Mark


(D)
6"
Top
Bird's Mouth
12"
6"

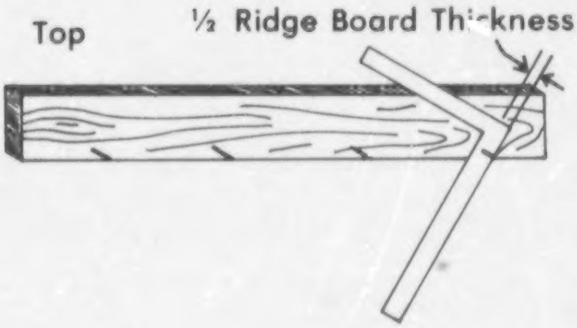
Step 5: With the heel of the square flush with the top of the board and the tongue set at the first bird's mouth cut (see c) of step 4), make a 1/2-inch long mark at the point where the body crosses the edge of the board. Move the square so that the tongue 6-inch mark is on the mark made along the body. Repeat 4 more times. Each step of the square measures one foot of run so 6 steps are necessary.

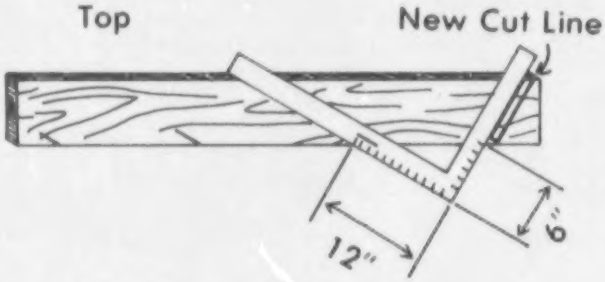

6"
12"
Top
Mark
Mark
Mark
Mark
Mark
6" Overhang
½" long Mark

Step 6: Cutting the ridge cut is important to insure strength at the point of the roof. The mark for cutting is determined by reversing the square from Step 5 so that the body aligns with the fifth mark resting at the 12-inch mark of the square and the sixth mark of the 6-inch mark of the tongue of the square coinciding. Draw a line along the tongue's outer face to mark the ridge cut.


Top
Ridge Cut Mark
Sixth Mark
Fifth Mark
12"
6"

Step 7: The last step is to allow for the ridge board. Measure back from the ridge cut mark 1/2 the thickness of the ridge board to mark the true cut line. If the opposite side rafter will be directly connected (rare), eliminate this step.


Top
½ Ridge Board Thickness


Top
New Cut Line
12"
6"

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 1 - How are the water needs checked against available supply?

Objective: Upon conclusion of the lesson, students will be able to tell how much water is needed to meet home and farm needs.

Study Questions:

1. How is the amount of water needed per day determined?
2. What are the types of water sources?
3. How is the availability determined?
4. What are the possibilities of increasing water yield?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 1 - How are the water needs checked against available supply?

TEACHING PROCEDURE

A. Review

B. Motivation: What type of water system is used on your farm? How much flow pressure does it have? Is the rate sufficient for the farm? How could it be increased?

C. Assignment: Find out the type of pump on your farm and the number of waterlines. Could the system handle a larger pump?

D. Supervised Study

E. Discussion

1. How do you calculate the water needed per day? What do you include in the calculations?

   How is the amount of water needed per day determined?

   1) Find the approximate daily needs.
      a) Home needs 100 gallons per person.
      b) Lawn and garden needs 600 gallons per 1,000 square feet to apply 1 inch of water.
      c) On the farm, dairy cows need 20 gallons per head; dry cows need 15 gallons per head; calves need 7 gallons per head; beef cows need 12 gallons per head; finishing hogs need 4 gallons per head; brood sows need 6 gallons per head; flushing floors need 10 gallons per 100 square feet.
   2) Daily needs is the sum of above.

2. The water source needs to provide all the water needs of the farm throughout the year. Check for adequacy for the present and for future expansion.

   What are the types of water sources?

   1) Types of water sources will vary with the section of the country. Types include:
      a) Drilled wells
      b) Driven wells

c) Jetted wells
d) Dug wells
e) Bored wells
f) Springs
g) Cisterns
h) Lakes and ponds

2) Drilled wells
  a) Steel pipe (casing)
  b) Four- to 8-inch diameter
  c) Thirty to 40 feet to several hundred feet of depth
  d) Percussion type drill or a rotary drill is used.

3) Driven wells
  a) Point and screen attached to 1 1/4- to 2-inch pipe driven like a post.
  b) Generally 25 to 100 feet depth in loose soils
  c) Furnishes less water than other methods but two wells can be connected to one pump

4) Jetted wells
  a) Pump forced water goes down center pipe to wash out soil.
  b) Soil-water mix goes up the outside pipe.

5) Dug wells
  a) Three- to 20-feet diameter
  b) Less than 50 feet deep
  c) Cased with tile, stone, or brick

6) Bored wells
  a) Dug with earth auger
  b) Eight- to 14-inch diameter by hand
  c) Up to 3-feet diameter by hand
  d) Up to 100 feet deep
  e) Tile lined

7) Springs
  a) Generally in rolling or mountainous areas
  b) Usually limited supply

8) Cisterns
  a) Rainwater
  b) Need careful protection from pollution
  c) Filter systems are a must.

9) Lakes or ponds
  a) Manmade or natural
  b) Pollution is a problem.
  c) Need good filter systems

3. After the water source has been determined, it is important to find out how much the source will provide. How is this done? Can the farmer perform this task?

How is the availability determined?

1) Drilled well
   a) Driller can use a bailer to record water yield.
   b) Use drawdown to check for water level drop in the bottom of the well.
   c) Test pump for 4 to 5 hours or up to 24 hours to determine flow of water.
   d) For on-farm measurement, measure water flow for 5 minutes by catching water in buckets. Calculate gallons: Multiply gallons collected at flow by 12 for gallons per hour.
2) For jetted, driven, bored, or dug well:
   a) Use test pump.
   b) Check drawdown.
   c) If well is too small to check drawdown with float, use a pressure tube.
   d) Another method is to use feet of vacuum.
3) Springs can be measured by bucket fill.
4) Cisterns are limited by rainfall catchment.
   a) Square feet of roof length by depth in feet yields gallon size.
5) Lake, pond, and reservoir water estimate
   a) Measure length and width.
   b) Calculate square feet area--L x W.
   c) Measure depth at deepest point. Multiply by .4 to determine average depth.
   d) Determine cubic feet of water. L x W x D.
   e) Multiply cubic feet by 80% for true yield
   f) Gallons = cubic feet x 7.5 gallons per cubic feet.

4. After a well has been used for some time, the rate of flow may decrease. What would cause this?

   What are the possibilities of increasing water yield?

   1) Drilled well
      a) Problems can be build-up of deposits on screen, collection of fine materials in water bearing area, or collection of slime caused by bacteria.
      b) Corrections are backwash, acid treatment, shock chlorination, or high velocity jetting.
   2) Driven and jetted wells are less costly to drill or deepen than drilled wells.
   3) Dug and bored wells
      a) Clean out sediment.
      b) Deepen well if water table has lowered.
   4) Spring can be cleaned to increase water flow.

5) Cisterns
    a) Check for possible leaks.
    b) Increase drainage area.
6) Ponds
    a) Check for leakage.
    b) Fine silt can accumulate; dredge.

F. Summary

Consult your local Soil Conservation Service Office for information on the best system for your area. With the amount of pollution in the air today, surface water and rain can be polluted very easily. A good example is London, England, where large amounts of coal are burned and sulfur dioxide is released into the air. Rain mixes with the air to form H_2SO_4, sulfuric acid, which eats paint, metal, and other materials.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. T
5. F
6. Any five of the following:

    a. Drilled
    b. Driven
    c. Jetted
    d. Dug
    e. Bored
    f. Springs
    g. Cisterns
    h. Lakes

178

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 1 - How are the water needs checked against available supply?

EXAM

T F 1. When planning for home water needs, include 100 gallons per person per day.

T F 2. Brood sows need 6 gallons per head per day.

T F 3. Driven wells are usually deeper than drilled wells.

T F 4. For a true measure of capacity, the well should be test pumped for 24 hours.

T F 5. The easiest method of increasing production of a well is to redrill the hole.

6. Name 5 types of water sources.

a.

b.

c.

d.

e.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 2 - What is needed to provide safe water?

Objective: Upon the conclusion of the lesson, students will be able to explain how water becomes polluted and how to prevent it; to describe how to deterimine if water is safe to use; and to describe methods for disinfecting water.

Study Questions:

1. What is safe water?
2. How are wells and springs protected from pollution?
3. How is pollution controlled in cisterns?
4. How is pollution reduced in ponds and small lakes?
5. How is the water supply determined as safe?
6. What methods are available for disinfecting water?
7. How does the chlorine method of disinfecting water work?
8. How do the pasteurization and ultra-violet methods of water disinfection work?
9. Which disinfecting method should be used?
10. How are water sources protected from radioactive fallout?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 2 - What is needed to provide safe water?

TEACHING PROCEDURE

A. Review

B. Motivation: How is your home water system protected from pollution and treated for bacteria? What are some ways a well can become polluted?

C. Assignment: Look for possible pollution points on each student's water source.

D. Supervised Study: Have several water sources in the community tested for pollution; include ponds, lakes, and well water. It can be analyzed by EPA.

E. Discussion

1. What makes clean drinking water? What diseases are carried by water? Where are the sources of trouble? Discuss and list problems.

   What is safe water?

   1) Safe water is free of harmful bacteria, viruses, and parasites.
   2) Water can carry hepatitis and polio.
   3) Water can carry animal diseases--leptospirosis, anthrax, brucellosis, tuberculosis.
   4) EPA found 59% of rural water systems polluted with bacteria and fecal matter.

2. Pollution is a major problem of water systems, especially shallow wells. How can they be protected? What sources of pollution are a problem?

   How are wells and springs protected from pollution?

   1) Wells and springs need watertight well casings or spring housing.
   2) Surface area should not drain directly into the well or spring.
   3) Water source should not be too shallow because pollution could enter as a result of only a few feet of soil coverage.
   4) A well should not be too close to septic system.

5) To protect a well:
    a) Protect from entry directly into top of well
    b) Protect entry below ground level
    c) Protect from pollution between casing and soil around it
    d) Fence livestock 100 feet away from well.

3. How does a cistern system work? What are the sources of pollution? How are they controlled?

How is pollution controlled in cisterns?

1) Use of a disinfecting unit is strongly recommended for a cistern.
2) Pollution is lower if the first rainwater, which washes off wastes, is diverted away from the cistern.
3) Automatic systems of diversion are available.
4) Check for structural problems as sources of pollution.
5) Filter incoming water to remove solids; clean filter regularly.

4. The hardest water source in which to control pollution is a pond. Runoff must be carefully controlled to prevent pollution.

How is pollution reduced in ponds and small lakes?

1) The watershed should be:
    a) Clean, grassed
    b) Free of drainage fields from farm
    c) Protected from erosion
    d) Fenced from livestock
2) The pond should be:
    a) Not less than 8 feet deep
    b) Average over 3 feet deep
    c) Able to store enough water for a year
    d) Fenced
    e) Free of weeds, algae, floating debris

5. Who can test the home water supply? How do you take a water sample?

How is the water supply determined as safe?

1) Collect a sample.
    a) Select a cold-water faucet.
    b) Remove any attachments.
    c) Let water run for 2 minutes.

180

    - d) Reduce flow and fill sterile bottle with water.
    - e) Send samples to laboratory.
- 2) It will be checked for coliform bacteria.
- 3) A coloring agent is used to check for underground contamination; fluorescin is recommended.

6. Water that carries some polluted matter needs to be treated before drinking. How is this done? What is available to purify water?

   What methods are available for disinfecting water?

   - 1) Chlorine, heat, and ultra-violet light are used.
   - 2) Iodine is a possible method to use.
   - 3) Consult state and local regulations.

7. What type of disinfecting systems do you use? What type of system is used in commercial water systems? How is flow measured?

   How does the chlorine method of disinfecting water work?

   - 1) Usually 1 to 5 parts chlorine to 1,000,000 parts water
   - 2) Parts per million (ppm) 1 to 5
   - 3) For home chlorine supply, use diluted or low-grade forms of chlorine.
   - 4) Sodium hypochlorite for home supply of chlorine
     - a) Water-and-chlorine mix (domestic laundry bleach)
     - b) Two strengths--domestic, commercial
     - c) 5.25 percent chlorine--domestic
     - d) 10 to 19 percent chlorine--commerical
   - 5) Calcium hypochlorite for home supply of chlorine
     - a) Available in powder or tablet
     - b) Thirty to 75 percent active chlorine
   - 6) Pump type chlorinator is powered by water or electricity.
     - a) Use of wobble-plate system with check balls is popular.
     - b) Uses suction from tank of solution
     - c) Incorporates chlorine solution into delivery line
   - 7) Injecter type, aspirator, or jet chlorinator
     - a) Water is forced through venturi causing suction from chlorine tank.
     - b) Water with chlorine is injected back into the waterline.
   - 8) Tablet type chlorinator
     - a) Water is forced through tablets by restrictor valve.

b) Water is returned--chlorinated--to the water system.

8. The method used to pasteurize milk commercially can also be applied to water systems. Heat is a proven killer of bacteria. Discuss the heat action and its costs in energy.

How do the pasteurization and ultra-violet methods of water disinfection work?

1) Water pasteurizers are adaptive to smaller water supplies.
2) The principle is to heat water to about 150°F in a heat exchanger.
3) Then heat water to 161°F for 15 seconds.
4) Pasteurization is limited to 20 to 24 gallons per hour.
5) Ultra-violet light method kills large amounts of bacteria with 2,537 Angstroms of light.
6) Water circulates around light, which is sealed from the cooling action of water.
7) Ultra-violet method can handle up to 20,000 gallons per hour.
8) Ultra-violet method can be set up for continuous use.

9. Although several good methods of water disinfection are available, you must select the method best suited for your particular needs. What factors must be considered? How does the type of water in your area affect selection?

What disinfecting method should be used?

1) Small quantities of chlorine are needed to kill bacteria and viruses.
2) Dosage is the amount added.
3) Organic matter and minerals can "use up" chlorine.
4) Ammonia can "tie up" chlorine.
5) Add enough chlorine to have "residual"--left over chlorine.
6) Chlorine is favored because:
    a) Chlorine residual lasts a long time for continuing protection.
    b) A test kit is used regularly to determine protection.
7) Simple chlorination requires:
    a) Chlorine for everyday needs is .5 to 1 ppm.
    b) Residual of chlorine is .2 to .5 ppm.
    c) Contact time of chlorine and water should be 20 minutes.

8) Chlorine effect increases
   a) As residual increases
   b) Contact time increases
9) Chlorine effect decreases
   a) As water temperature lowers
   b) Alkalinity increases
10) Test residual after 29 minutes of contact time.
11) Contact time can be improved by:
   a) Using a storage tank
   b) Using a reservoir
   c) Feeding chlorine into a well near a pump
12) Superchlorination is used to reduce contact time.
   a) A residual of 3 ppm requires a contact time of 5 minutes.
   b) A residual of 5 to 6 ppm requires 7 minutes of contact for the best results.
13) Always follow directions.
14) Test kits are readily available.

10. In case of nuclear attack, safe water--that protected from radioactive fallout--becomes important. Protection from falling radioactive dust can be easily accomplished by simple coverings.

How are water sources protected from radioactive fallout?

1) Open water supplies such as ponds, lakes, and streams are readily contaminated.
2) Cover wells and springs to exclude dust.
3) Underground supplies are protected by the soil.
4) Household water softeners will remove radioactive material.

F. Summary

The best way to know if a water system is safe is to test the water for bacteria and viruses. If counts are high, then protective measures are needed to prevent diseases in humans and livestock.

G. Evaluation

Answers to Exam

1. F
2. F
3. T
4. T
5. F
6. a. Cholorination
   b. Heat
   c. Ultra-violet
7. a. Sodium hypochlorite
   b. Calcium hypochlorite

184

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 2 - What is needed to provide safe water?

EXAM

T F 1. Water is safe as long as it comes from an underground source.

T F 2. A shallow water system is best because it takes less energy to remove the water.

T F 3. Livestock should be fenced 100 feet from the water source.

T F 4. A pond source of water should have the capacity to supply water for one year.

T F 5. Contact time for simple chlorination should be 20 to 30 seconds.

6. What are the three methods of water disinfection presently in use?

   a.

   b.

   c.

7. Two sources of chlorine for home use are:

   a.

   b.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 3 - How is the need for water conditioning determined?

Objective: Upon the conclusion of the lesson, students will be able to determine the need for water conditioning, to describe the methods of water conditioning, and to give the advantages and disadvantages of each method.

Study Questions:

1. What water problems demand conditioning?
2. How is the probable cause of poor water quality determined?
3. How is the extent of the water quality problem measured?
4. What methods are available to correct the quality problems?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 3 - How is the need for water conditioning determined?

TEACHING PROCEDURE

A. Review lesson 2 on safe water.

B. Motivation: What causes water to change color? Are these changes dangerous to people? How are these problems controlled and rectified?

C. Assignment: Collect water samples that look polluted and have them analyzed for minerals and acids.

D. Supervised Study: Dissolve the following in water to show types of pollution: (1) iron oxide; (2) copper sulfate; (3) calcium carbonate; (4) carbon dioxide; and (5) magnesium. Compare the colors and discuss the controls of each type of pollution.

E. Discussion

1. What problems will require that the water in your home system will need conditioning? What symptoms are present in a system that needs water conditioning?

   What water problems demand conditioning?

   1) Water can carry minerals, acids, or foreign matter.
   2) Red or black particles or an odor or taste may be in water.
   3) Corrosion problems in pipes can occur.
   4) Water can become chemically active (acidic).
   5) Tastes and odors from decaying vegetation in soil may demand attention.

2. Different water problems have different types of symptoms and causes.

   How is the probable cause of poor water quality determined?

   1) Hardness
      a) Hardness is usually caused by calcium and magnesium.
      b) Aluminum and iron contributes to hardness.
   2) Red water (iron)
      a) Red water is caused by water passing through iron deposits in soil or from pipe and pump parts as low as .1 ppm.

   b) Bacterial action on iron in water causes slippery, jelly-like coatings.
   c) Taste, staining properties, and settling in containers are indications of iron in water.
   d) Red coating forms when iron-rich water mixes with air.

3) Brownish-black water (manganese)
   a) Manganese causes dark brownish-black stains.
   b) Manganese can settle out as a sediment.
   c) At .15 ppm problems can arise.
   d) Manganese can clog pipes.

4) Acidity (carbon dioxide)
   a) Sources are organic matter or rain water.
   b) Carbon dioxide concentration of 0-50 ppm is normal. If carbon dioxide goes to 300 ppm, there is a problem.
   c) In mining areas, sulfuric, nitric, or hydrochloric acids may be present.
   d) Acid water "eats up" metal pipes.
   e) If you also have an iron problem, acid water prevents complete removal of iron.

5) Off flavor (rotten egg odor or taste)
   a) In ponds decaying organic matter or algae cause off flavor.
   b) Chemical waste can cause off flavor.
   c) Oily taste from storage tanks cause off flavor.
   d) Chlorine taste is off flavor.
   e) Hardness, iron, and acidity are other causes of off flavor.

6) Turbidity (dirty or muddy)
   a) Clay and silt are washed from surroundings.
   b) There may be a collection of organic matter and algae.

3. How is the water problem identified? What tests are available? Can the problem be pinpointed?

How is the extent of the water quality problem measured?

1) Kits are available from local dealers to test for hardness, iron, and acidity. (See Table VIII, page 53, of the reference.)
2) Water samples can also be sent to laboratories for a complete analysis. Health department and educational agencies can sometimes analyze water samples.

4. After the source of the problem has been determined, how can we correct it? Methods are available for water improvement. (See Table VIII, page 53, of the reference.) (Information is in detail in lesson 4.)

   What methods are available to correct the quality problem?

   1) Ion-exchange softener dissolves iron, calcium, manganese, and magnesium.
   2) Chlorinator controls iron bacteria and dissolves iron, manganese, and rotten egg odors.
   3) Soda-ash or limestone filter neutralizes acids.
   4) Activated-carbon filters control off flavors.
   5) Sand filter controls turbidity.

F. Summary

Water in certain geographical areas contain large amounts of dissolved minerals which can clog pipes or corrode pipes and pumps. The method of removing these minerals that is most common is ion-exchange through water conditioning. Consult a local expert when planning for proper conditioning of the farm water system.

G. Evaluation

Answers to Exam

1. a. Minerals
   b. Acids
   c. Foreign matter
2. a. Calcium
   b. Magnesium
3. a. Dissolved iron
   b. Iron bacteria
4. T
5. T
6. T

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 3 - How is the need for water conditioning determined?

EXAM

1. Water can carry three main types of problems that need conditioning. They are:

   a.

   b.

   c.

2. Hardness is caused by:

   a.

   b.

3. Red water is caused by two factors:

   a.

   b.

T F 4. Acidity of a water system can be increased by rain water.

T F 5. A chlorinator can solve an iron bacterial problem.

T F 6. An activated-carbon filter will remove most off flavors.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 4 - What methods of water conditioning are available?

Objective: Upon conclusion of the lesson, students will be able to describe the methods of water conditioning and to give the advantages and disadvantages of each method.

Study Questions:

1. What are the means for controlling water hardness?
2. What are the means for controlling iron in water?
3. What are the means for controlling acid flavor?
4. What are the means for controlling off flavor in water?
5. What are the means for controlling turbidity in water?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 4 - What methods of water conditioning are available?

TEACHING PROCEDURE

A. Review lesson 3 on need for water conditioning.

B. Motivation: Are stains visible in washing or in cups on your farm? Are there strange tastes or odors in the water? How are they corrected?

C. Assignment: Find out if the students' homes have a water conditioner. If they do, have them describe its setup and what the water is being conditioned to remove.

D. Supervised Study: Set up sample conditioners with the help of local water conditioner installers and filter different solutions of water.

E. Discussion

1. Levels of water hardness vary with the type of soil and part of the country in which you live. There are seldom more than one or two water conditioning problems with any one water source. What causes water hardness? What minerals cause water hardness?

   What are the means for controlling water hardness?

   1) Over 3.5 grains of hardness per gallon is hard.
   2) Missouri water is hard to very hard.
   3) Reverse-osmosis units
      a) This method is forcing water through a membrane.
      b) Membrane filters calcium, magnesium, dirt, viruses, and bacteria.
      c) It is a slow process but advantageous over ion-exchange for people with heart, kidney,
      d) Membrane needs changing every one to three years.

   4) Ion-exchange units
      a) Water passes through water softening material, i.e. zeolite.
      b) Water softens by exchange of sodium from zeolite for calcium or magnesium.

   - c) Water softener material is recharged by passing salt brine through exchange material.
   - d) Water softener can be a one- or two-tank system. A one-tank system is only the softener. Two-tank system requires a brine tank softener for recharging.
   - e) Recharging depends on water hardness.
   - f) Recharging can be done automatically.

2. Iron in the water system can cause staining and a metallic taste. If the water contains over .3 ppm iron, a problem is suspected. List the symptoms on the board and the methods for controlling this problem.

   What are the means for controlling iron in water?

   1) Most common methods
      - a) Phosphate feeders will control dissolved iron.
      - b) Ion-exchange units will control dissolved iron.
      - c) Oxidizing filters will control dissolved iron.
      - d) Chlorinator-and-filter units will control dissolved iron and/or bacterial iron.
   2) The method selected will be influenced by:
      - a) Amount of iron present (ppm)
      - b) Form of iron
      - c) Other water quality problems
   3) Phosphate feeder can handle up to 2 ppm iron.
      - a) Phosphate feeder will not work on oxidized iron or bacteria.
      - b) Phosphate feeder is recommended to use with water softener to prevent iron build-up in zeolite.
      - c) Phosphate feeder needs recharging about every 30 days.
   4) Ion-exchange units can handle up to 10 ppm iron if water has not been exposed to air.
      - a) Certain types of zeolite will remove iron.
      - b) System will not control iron bacteria.
      - c) If iron is oxidized, problems with settling will occur.
   5) Oxidizing filters are used for removing up to 10 ppm of iron.
      - a) Iron removal filter unit contains manganese-treated green sand.
      - b) Iron particles settle out as rust.
      - c) Maintenance is backwashing and rinsing the filter weekly and recharging.
      - d) Recharge iron-removed filter with potassium permanganate weekly or monthly.

6) Chlorinator-and-filter units
    a) Chlorinator will handle any amount of any type of iron.
    b) The filter strains iron and kills the bacteria.
    c) Water must be low acid or no acid for maximum efficiency
    d) Maintenance same as for disinfecting equipment.
7) Manganese is controlled by methods used to control iron.

3. When the water is tested and an acid condition is found, neutralization must occur. How are acids neutralized? What is pH? (measure of acidity or alkalinity)

What are the means for controlling acid flavor?

1) Soda-ash or caustic-soda feeder
    a) Soda-ash and chlorine can be used together
    b) Feed into well to protect pump parts and water.
    c) Soda-ash adds no hardness.
    d) Ratio is 1/2 pound soda-ash to one gallon soft water; feed into water supply; 100 pounds lasts 2 to 3 weeks.
2) Neutralizing tank
    a) Neutralizing tank has a bed of marble or limestone chips.
    b) It has a slow feed rate.
    c) Neutralizing tank can increase water hardness when limestone is used.
    d) Maintain by backwashing; replace dissolved chips yearly.

4. Bad flavors often get into a water system. What causes these problems? How are they controlled?

What are the means for controlling off flavor in water?

1) Off-flavor water includes rotten egg odor and taste, metallic taste, salty taste, and chlorine taste.
2) Activated carbon filter will overcome bitter, fishy, marshy, brackish or oily taste.
3) Two types of activated carbon filters
    a) Precoat cartridge type
    b) Carbon-bed type
4) Activated carbon filters absorb dissolved gases; filters divide solids and certain insecticides.
5) Maintenance
    a) If precoat cartridge type, remove and replace filter.

    - b) In a precoat system, wash components, then recharge after several months.
- 6) Bed-type filters can be backwashed and then recharged yearly.

5. The suspension of solids in ponds and other surface water sources is a problem in water supplies. What causes turbidity? How can it be prevented? (Refer to lessons 2 and 3.)

   What are the means for controlling turbidity in water?

   - 1) Over 10 ppm turbidity is objectionable.
   - 2) Three approaches to control turbidity:
     - a) Open-pond method removes heavy part of turbidity.
     - b) Turbidity treatment units may be used.
     - c) Combination of the above two methods may also be used.
   - 3) Open-pond treatment
     - a) Coagulation and sedimentation are used to remove fine sediment. Add powered gypsum at a rate of 12 pounds per 7,000 gallons water.
     - b) Algae is controlled by copper sulfate. Follow manufacturer's recommendations.
   - 4) Turbidity treatment systems
     - a) If less than 40 ppm, filter the system.
     - b) If over 40 ppm, use a settling tank filter.
     - c) Locate screened inlet 12 to 18 inches below surface.
     - d) Settling tank is used for large particles.
     - e) Alum solution glob attracts and settles solids.
     - f) Slow sand filter 27 to 75 gallons per day per square foot of filter bed.
     - g) Storage tank is used for passive settling.
   - 5) Diatomite filter
     - a) Filters with diatomaceous-earth
     - b) Suspends solids by straining method
     - c) Ten to 100 times faster than sand filter
   - 6) Rapid sand filter
     - a) This works by pressure feeding water so that water is forced through filter
     - b) It is effective on large particles.
     - c) It needs filter aid (chemical) when used with pond water.
     - d) Maintain by backwashing every 7 to 10 days.

F. Summary

Selection of filtering systems is based on the present water system and the problems now being encountered. Be sure the system meets the problem.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. T
6. F
7. T
8. F
9. F
10. F

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 4 - What methods of water conditioning are available?

EXAM

T F 1. Missouri water is not considered to be hard.

T F 2. Ion-exchange units trade sodium ions for calcium and magnesium, making the water softer.

T F 3. Iron causes the water to turn bluish, leaving blue stains in clothing.

T F 4. The chlorinator-and-filter unit is the only practical method available that will control both iron and iron bacteria.

T F 5. To neutralize the acid in water, we use a base solution of soda-ash.

T F 6. Less maintenance is required for a limestone acid neutralizing tank than other acid neutralizing systems.

T F 7. Most bad odors can be easily controlled by carbon filters.

T F 8. Turbidity is only a problem if it is greater than 100 ppm.

T F 9. Algae turbidity is controlled by powdered gypsum added to the pond surface.

T F 10. Rapid sand filters are best because they provide large volumes of clear, clean water.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 5 - How is the type of pumping installation determined?

Objective: Upon the conclusion of the lesson, students will be able to determine what pumping capacity will be needed to meet peak water-use demands and to determine what type and size pump to select to meet the water-use demands.

Study Questions:

1. What capacity pump is needed?
2. What are the different pump types available?
3. How is the type of pump needed determined?
4. How is the type and size of water storage system determined?
5. What are the water-system control units?
6. What housing is needed for pump and water storage?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING WATER SYSTEMS

Lesson 5 - How is the type of pumping installation determined?

TEACHING PROCEDURE

A. Review lesson 1.

B. Motivation: What size pump does each student's home have? Can it deliver enough water for the family needs? Is there a storage system available?

C. Assignment: Check the size of the home pump and find maximum velocity, gpm, horsepower, and storage capacity.

D. Supervised Study: Select the proper size pump for a hypothetical water system. Calculate a water system for a farmhouse and small feeding operation. Do all work on board through handouts.

E. Discussion

1. How is the size (horsepower) of the pump determined? What must be calculated to find this pump size? How many gallons per minute are needed?

   What capacity pump is needed?

   1) At the peak demand, how many gallons per minute at maximum load are needed?
   2) Two types of water usage
      a) Intermittent--Usage of water lasts 5 minutes or less.
      b) Sustained--Usage of water lasts more than 10 minutes.
   3) Types of uses of water are in Table IX, page 77, of the reference.
   4) To find peak demand for pump:
      a) Calculate capacity needed for household use.
      b) Calculate capacity needed for irrigation, cleaning, and miscellaneous.
      c) Calculate capacity needed for watering livestock and poultry.
      d) Look at the examples on pages 76 through 79 of the reference.
   5) Capacity for fire protection
      a) Need minimum of 10 gpm of water for one 1/4-inch fire nozzle.

199

   b) Need 25 gpm of water for 3/8-inch nozzle or two 1/4-inch nozzles.

2. After the demands have been calculated, you are ready to select a pump for the demands. What types of pumps are available in your area? Are pumps interchangeable with the different water sources? Gather manufacturer's booklets on the different pump types to use in class.

   What are the different pump types available?

   1) Pumps operate on suction and pressure.
   2) Lifting of water by suction is limited to a maximum of 25 feet.
   3) Suction system uses a vacuum to lift water.
   4) Air leak in pipe destroys suction.
   5) Piston pump
      a) Piston pump can be single or double action with one-way valves.
      b) If water is over 25 feet, use deep-well piston with water push and little suction.
   6) Centrifugal pump
      a) Centrifugal pump is a suction pump with no air in pipe.
      b) Centrifugal pump is shallow and has a lift of 15 to 18 feet only.
      c) Deep-well pumps are called submersibles and they push water upward.
      d) Multi-stage units increase pressure by increasing impellers.
      e) Air in lines will end pumping.
   7) Centrifugal-jet pump
      a) A centrifugal pump with a jet system added increases flow of water.
      b) The jet is a water nozzle flowing under pressure in a venturi or diffuser to draw more water.
      c) In a shallow-well, the ejector is located near the pump for suction from water flow.
      d) In a deep-well, ejector is located at bottom of the well.
   8) Turbine pump
      a) Operation is similar to centrifugal pump.
      b) Also some propelling or paddling is done by turbine pump.
      c) Shallow well can pump some air.

3. After capacity has been determined and the different types of pumps have been studied, we must determine the best pump for the job. What factors must we consider? List on the board the seven factors to consider.

How is the type of pump needed determined?

1) Review Tables X, XI, and XII on the ranges of pumping capacity before beginning study.
2) Depth of water
    a) If water level is never lower than 15 to 25 feet below pump, shallow-well unit can be used.
    b) If over 25 feet or if there is a steady lowering of the water level, use a deep-well pump.
3) Well size (refer to tables)
    a) Deep-well piston pump can be used down to 2-inch diameter of casing.
    b) Eureka cylinder uses rubber packer.
    c) Double-acting deep-well cylinder delivers more water from a small pipe.
    d) Jet pumps with a 2- to 4-inch diameter needs packers to control water backflow.
4) Pressure range of 20 to 40 psi is standard.
    a) Research suggests increase pressure range to 30-50 psi or 40-60 psi because of more use of water and undersize pipe.
    b) High pressure for cleaning is 80 psi. Over 80 psi can remove paint or pit concrete.
    c) Special pumps to increase pressure to 80 psi are usually added at point of use.
5) Height water is lifted above pump.
    a) If water is lifted 20 feet above pump, problems with water pressure begin.
    b) It takes one pound of pressure to push water 2.3 feet.
    c) Heavier pump-and-motor combination is needed if water is lifted over 20 feet.
    d) If deep-well, add depth of well plus elevation to calculate size of pump to be used.
6) Pump location
    a) Off set pump from well to save on cost of building.
    b) All shallow-well systems can be off set
    c) In submersible pumps, only the tank is off set
7) Pump durability and efficiency
    a) Average life of pump is 11 years.
    b) Biggest problem is meeting needs or installation.
    c) With positive-acting pump, extra pressure can overload motor.
    d) Using a low pressure centrifugal pump for continual usage causes high wear.

- e) Pump efficiency can save 25 percent of operating cost. Pump efficiency is most important with a jet pump. Check specifications.

8) Dealer service
- a) Dealer will help with selection of pump based on consumer needs.
- b) Supply of parts in emergencies is part of dealer service.

4. If the water supply provides enough water, using the proper size pump, it is easy to select the right size of storage. Size will depend on source. What storage systems are used in your community? Are water tanks present? How is pressure maintained?

How is the type and size of water storage system determined?

1) The three factors to consider in storage are:
- a) Type of storage and how it works
- b) Amount stored
- c) Sanitation features

2) The four types of water storage are:
- a) Elastic pressure cells
- b) Pressure tanks
- c) Gravity tanks
- d) Reservoirs

3) Elastic pressure cells
- a) Elastic pressure cells have a 3 gallon capacity.
- b) Elastic liner expands to hold water and contracts to deliver water.

4) Pressure tanks
- a) Hydo-pneumatic is the most popular type of pressure tank.
- b) This system compresses air with water--then pressure delivers the water.
- c) This system has problems with air absorption in water reducing pressure.
- d) Loss of air is called waterlogging.
- e) Increasing air volume will increase the pressure of the water.

5) Gravity tanks
- a) Gravity tanks are an overhead storage system.
- b) Gravity tanks produce one pound of pressure for 2.3 feet of elevation.
- c) Water quantity is independent of pressure.

6) Reservoirs
- a) Water is stored at pump level.
- b) Reservoirs are usually poured concrete.
- c) Steel tanks are intermediate storage.
- d) With the intermediate system, a second pump is used.

7) When determining the amount to be stored, consider:
    a) Rate of water yield
    b) Reserve for fire fighting purposes
    c) Protection from nuclear explosion
8) Water supply yield
    a) Water supply yield is dependent on pump size and pressure system.
    b) Low yield system needs storage.
    c) Intermediate storage is dependent on the capacity of the pressure pump and other differences between the pressure pump and well pump.
9) Storage for fire
    a) 5,000 gallons should be stored for fire protection.
    b) Hydrant should be centrally located for fighting fires.
10) Protection for nuclear explosion
    a) You should reserve a 14-day supply with a minimum of 1/2 gallon per day per person.
    b) Cover storage of water and provide alternate pumping system in case of loss of electricity.

5. How is the flow of water controlled? How is proper pressure and flow maintained? How do water switches work? What kinds are available for automatic operation? (Have a local distributor demonstrate the operation of the controls or secure some of these units to demonstrate in class.)

What are the water-system control units?

1) Types of control units
    a) Water-supply control switches
    b) Air-volume pressure tank
    c) Pump-prime
    d) Pressure-relief
    e) Pressure gages
    f) Water-hammer
    g) Sand-removal
2) Water control methods
    a) Pressure
    b) Float
    c) Drawdown-control
3) Air-volume pressure tank
    a) Air-volume pressure tank is needed to prevent waterlogging and loss of pressure.
    b) Float type control system is used for piston pumps.
    c) Diaphragm type is needed for centrifugal, jet, and turbine type pumps.

4) Pump-prime controls
    a) Foot valves prevent water from escaping from pipe.
    b) Check valves prevent backflow of air.
5) Pressure-relief valves
    a) Pressure-relief valves protect pump if it fails to stop pumping.
    b) Pressure-relief valves are adjustable.
6) Pressure gages
    a) Pressure gages are helpful in locating trouble in system.
    b) Pressure gages are located on discharge side of pressure tank.
7) Water-hammer controls
    a) Water-hammer is the ramming action of water when turned on--then quickly off.
    b) Biggest problem when pumping uphill can be corrected with two pressure tanks or elastic cells.
8) Sand-removal is accomplished by a sediment trap.

6. How do you install the pump and water storage system? What type of protection will it need? Are freezing temperatures, dirt, or heat a problem?

    What housing is needed for pump and water storage?

    1) Protection from surface water entering well
    2) Adequacy of weather protection
    3) Adequacy of drainage
    4) Adequacy of ventilation
    5) Ease of cleaning enclosure
    6) Ease of servicing equipment
    7) Ease of servicing well

F. Summary

Careful planning of pumping facilities will provide a steady, productive system of water for all the uses on the farm.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. a. Type of storage
    b. Amount stored
    c. Sanitation features
6. Any three of the following:
    a. Water-supply control switches
    b. Air-volume pressure tank
    c. Pump-prime
    d. Pressure-relief
    e. Pressure gages
    f. Water-hammer
    g. Sand-removal

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 5 - How is the type of pumping installation determined?

EXAM

T F 1. Peak demand is measured in gallons per year usage.

T F 2. Suction pumps are generally ineffective in a well over 25 feet deep.

T F 3. A piston pump is usually installed at the bottom of the well and pushes water upward.

T F 4. A jet pump can be small enough to fit in a two-inch diameter well.

5. What are the three factors to consider when planning storage facilities?

   a.

   b.

   c.

6. Name three water-system control units.

   a.

   b.

   c.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 6 - How is the piping installation planned?

Objective: Upon the conclusion of the lesson, students will be able to draw a layout of the underground piping system, giving the sizes and dimensions needed to meet the demands.

Study Questions:

1. Where should the outside water outlets be located?
2. How is the piping layout planned?
3. What type of pipe should be used?
4. How is the proper supply-pipe size selected?
5. What protection is needed for the pipe?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 6 - How is the piping installation planned?

TEACHING PROCEDURE

A. Review attaching pipes together.

B. Motivation: Demonstrate soldering copper pipe and attaching sections of plastic pipe. How does the builder determine the lengths of pipe needed and the type of pipe to use? What problems can occur that can cause breaks in the lines?

C. Assignment: Find out what type of pipe is used on the student's farm and how the pipe was installed.

D. Supervised Study

E. Discussion

1. What factors are involved in deciding where to locate an outside water outlet? Does weather have an influence on placement? List on the board the answers of the class.

   Where should the outside water outlets be located?

   1) Locating the outlets for convenience
      a) One outlet per 100 feet around the house is convenient.
      b) A hydrant near the garden is convenient.
      c) In farm buildings location of outlets will depend on need.
      d) In loose housing, there should be a central outlet for watering tank.
      e) There should be a hot and cold outlet for milkhouse.
      f) Hog facilities need one or more outlets for waterers and floor cleaning.
   2) Locating outlets for fire protection
      a) Locate outlets at 100-foot intervals so a 50-foot hose can reach any point.
      b) Some hydrants should be located away from structures because of heat and smoke.

2. This section deals with how to plan for running pipes from the pump to where it is needed. This is based on demand and pressure needs. What needs to be considered? List items.

How is the piping layout planned?

1) Determine water demand at various locations.
    a) List all home uses and peak demand allowance
    b) Determine which use has greatest fixture-flow rate.
    c) Substitute fixture-flow rate of heaviest water use for peak demand allowance.
    d) Add any competing demand and total.
    f) Determine need for outdoor water.
2) Determine where to place the pipelines.
    a) Sketch buildings and grounds. (Use a scale.)
    b) Measure all distances between buildings and all buildings sizes. Record.
    c) Show demand at each location.
    d) Draw a double line from the pump to the greatest demand and mark it A.
    e) Draw a double line to next greatest demand and label it B.
    f) Check layout for ease of installation and maintenance.
    g) Locate cutoffs at pumphouse for lines of greatest demand.

3. There are several types of pipe available to use in the farm system. You need to carefully select the proper size and type for each job. What factors need to be considered?

What type of pipe should be used?

1) When selecting pipe, consider the kinds of pipe and probable life expectancy; resistance to corrosion, puncture, and rodents, and internal deposits; effect of freezing, sunlight, and water flavor, safe working pressure, lengths available; weight, ease of bending and ability to conduct electricity; comparative cost and ease of installation.
2) Kinds of piping
    a) Galvanized-steel is zinc coated.
    b) Copper types are "K" and "L" and are either soft or hard.
    c) Two types of plastic piping are flexible, polyethylene and polyvinyl chloride which comes in rigid 10-foot lengths.
    d) See table on page 132 of reference.
    e) Plastic is rated at 100 to 120 psi for PE pipe and up to 200 psi for PVC.

4. Now is the time to determine the diameter pipe to use to supply the water to the buildings. The size of the pipe can severely limit the water flow.

   How is the proper supply-pipe size selected?

   1) Amount of water a pipe will deliver at a set pressure is determined by:
      a) The size of pipe
      b) The smoothness of the inside of pipe
      c) The pipe length
   2) Cutoff valves
      a) Globe
      b) Gate
      c) Ball
   3) Fire protection
   4) Determine pipe size to serve one location.
      a) Determine total demand allowance.
      b) Determine distance from pumphouse.
      c) Determine proper pipe size. Use charts on page 137 of reference.
   5) Determine pipe size to serve two or more locations.
      a) Indicate water demand allowance for each use at each location.
      b) Select water use location farthest from pump to start plan.
      c) Compare demand allowance at most distant location with allowance on same branch line.
      d) Take out noncompeting demands.
      e) Determine water demand on line.
      f) Determine pipe line length.
      g) Determine pipe size needed.
      h) Determine pipe size for branch lines.
      i) Determine pipe size for main feeder line.
   6) Pipe size for fire protection for 10 gpm should be 1 1/4 inches.

5. What problems can disrupt the water system? How deep does the ground freeze? Are pipes exposed to livestock? List problems.

   What protection is needed for the pipe?

   1) Protection from freezing
      a) Missouri freezing depth is 3 1/2 feet to 6 feet.
      b) If pipes are not in use in winter, drain the line.
      c) Use stop-and-waste valves to drain the lines outdoors.

        - d) Provide insulation on exposed pipes.
        - e) Use electric heating tape with a thermostat on pipes.
        - f) Install frostproof hydrants, but drain them properly.
    - 2) Protection from mechanical damage
        - a) Protect pipes from damage due to machinery and livestock.
        - b) Fence off pipe from livestock.
        - c) If shallow pipelines, avoid laying pipe in paths of heavy equipment.

F. Summary

Good preplanning will provide an adequate supply of water at recommended pressures. Also be sure to provide protection for the system to lower maintenance needs.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. a. Galvanized
    b. Plastic
    c. Copper
5. a. Size of pipe
    b. Smoothness inside
    c. Pipe length

210

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 6 - How is the piping installation planned?

EXAM

T F 1. Outlets around the house should be located every 100 feet.

T F 2. Missouri soils freeze to a depth of 3 1/2 to 6 feet.

T F 3. Planning the system involves the hiring of a competent architect.

4. Name the three types of pipe used in farm systems.

   a.

   b.

   c.

5. What three factors determine the rate of flow of a pipe?

   a.

   b.

   c.

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 7 - How is the electrical installation planned?

Objective: Upon the conclusion of the lesson, students will be able to explain what wiring installation is necessary to protect the motor and the motor circuit.

Study Questions:

1. What is the proper wiring to use?
2. What electrical protection is needed?

Reference:

1. Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 7 - How is the electrical installation planned?

TEACHING PROCEDURE

A. Review

B. Motivation: What happens when small wires have a large load? What are fuses? How can a lowered current affect the operation of an electrical motor?

C. Assignment

D. Supervised Study: Show in class the effect of undersized wires by hooking motors to undersized wires. Explain and demonstrate to the class and have students work in small groups.

E. Discussion

1. How is the wire size determined? How does the wrong size wire affect performance and safety?

   What is the proper wiring to use?

   1) Electrical efficiency can drop in two ways if wire is too small.
      a) Useful life will be shorter because of overheating the wire.
      b) Energy will be lost in heat in the circuit.
   2) Wire size needed
      a) Two voltages available: 120 and 240
      b) Two hundred forty volts reduces heat loss. Smaller wire can be used.
      c) Copper wire has less resistance to electricity.
   3) Type of conductor needed
      a) Inside a building, use NM or NMC.
      b) For overhead wire, use TW, THW, or SE.
      c) For underground wire, use UF or USE.
   4) Use wire tables on page 145 of reference.

2. The best system can be disrupted by one bolt of lightning. Protection is easy to provide. What is available?

   What electrical protection is needed?

1) The major problems are overloading and lightning surge.
2) Provide circuit protection for water system fire protection.
   a) Run a separate fused feeder directly to the pump from the output side of the main disconnect.
   b) Then the main service can be disconnected without interrupting the pump power.
3) Pump motor protection
   a) Install an overload protection device.
   b) Use circuit breakers, time delay fuses, or magnetic switches.
4) Lightning protection
   a) Lightning protection is important on submersible pumps.
   b) Use lightning arrestor in service box.
   c) Use lightning arrestor in motor control box.
   d) Use driven copper rod and bare copper wire to remove surge.

F. Summary

Water systems are primarily operated using a source of electrical power. For the farm, at least one 240-volt electric circuit is needed to power the pump system. Be sure to provide ample circuit protection from overload or lightning surges.

G. Evaluation

Answers to Exam

1. F
2. a. Heat in circuit
   b. Shorten life of equipment
3. a. Surge from lightning
   b. Overloading

214

UNIT - PLANNING FARM WATER SYSTEMS

Lesson 7 - How is the electrical installation planned?

EXAM

T F 1. Conductors are the same for overhead and underground lines.

2. Name two ways power can be lost if the wire is too small.

a.

b.

3. What are the two reasons to protect the electrical system?

a.

b.

UNIT - PLANNING FARM WATER SYSTEMS

ASSIGNMENT SHEET

Objective: By the conclusion of the assignment, the student will be able to calculate the peak demand for a farm and storage capabilities of water sources.

Charts Required:

Planning for an Individual Water System, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $5.25

Chart 1: Approximate Daily Water Needs for Home and Farm, p. 10
Chart 2: Pump Sizing Based on Water Demand, p. 77

Procedure:

PART 1: DAILY WATER NEEDS

Calculate the approximate daily water needs for the farm. Use Chart 1.

Step 1: Calculate the water needs for a farm with the daily water needs chart of:

_____ = 200 dry cows

_____ = 150 calves

_____ = 400 finishing hogs

_____ = Flushing floor for hogs, 1200 square feet

_____ Maximum water needs

PART 2: WATER IN SMALL POND

Calculating the amount of water in a small pond or lake.

Example: To calculate the amount of water in a small lake you must first find the cubic feet capacity, multiply times 80% which is the amount of available water, and finally multiply times 7.5 gallons of water per cubic foot of area.

Specifications of the pond
1) 100 feet wide
2) 300 feet long
3) 10 feet deep at deepest point

Step 1: 100 x 300 = 30,000 square feet

Step 2: Average depth is equal to .4 times greatest depth.
30,000 sq. ft. x (.4 feet x 10 feet)
30,000 sq. ft. x 4 ft. = 120,000 cubic feet

Step 3: 80% x 120,000 cubic feet = 96,000 cubic feet available water

Step 4: 7.5 gallons per cubic foot x 96,000 cubic feet = 720,000 gallons

PART 3: YOUR PROBLEMS

Problem 1: A lake - 200 feet wide
450 feet long
20 feet deep at deepest point

Problem 2: A pond - 55 feet wide
150 feet long
15 feet average depth

PART 4: WATER PEAK DEMAND

Calculate the peak demand gallons per minute needed for our farm in Part 1. Use the chart on pump sizing to find gpm required. (Chart 2) The item which has the highest gpm flow of all items should use the right column (individual fixture flow rate) value to insure a full flow when everything is on.

Specifications: Beef calves are in open housing.
Dry cows use a watering tank, 3 in lot.
Hogs are in confinement.
Floor cleaning.

CHART 1

Approximate Daily Water Needs

	Water Consumption per Day (gallons)
Dairy Cows	20 per head
Dry Cows and Heifers	15 per head
Calves	7 per head
Beef yearlings	20 per head
Beef, brood cows	12 per head
Sheep	2 per head
Horses	12 per head
Swine finishing	4 per head
Brood sows	6 per head
Flushing floors	10 per 100 sq. ft.
Hog Wallow	100 per day

CHART 2

Pump Sizing Based on Water Demand

Irrigation, Cleaning and Miscellaneous	Peak Demand Allowance (For Pump)	Individual Fixture Flow Rate
Lawn irrigation (per sprinkler)	2.5	(5.0)**
Garden irrigation (per sprinkler)	2.5	(5.0)
Automobile washing	2.5	(5.0)
Tractor and equipment washing	2.5	(5.0)
Flushing driveways and walkways	5.0	(10.0)
Cleaning milking equipment and milk storage tank	4.0	(8.0)
Hose cleaning barn floors, ramps, etc.	5.0	(10.0)
Swimming pool (initial filling)	2.5	(5.0)
Drinking Water for Farm Animals and Poultry*		
Dairy cattle:		
Confined housing - one stanchion dringing cup for each 2 cows	.75 per cup	(1.5 per cup)
Open housing - up to 8 head per waterer space	.75 per space	(1.5 per space)
Beef cattle:		
Open housing - up to 40 head per waterer space	.75 per space	(1.5 per space)
Hogs:		
Confined housing - up to 10 pigs per waterer space	.25 per space	(0.5 per space)
Open housing - up to 25 pigs per waterer space	.25 per space	(0.5 per space)
Horses:		
Confined housing - 1 watering space per 2 stalls	.75 per space	(1.5 per space)
Open lot - up to 10 horses per watering space	.75 per space	(1.5 per space)
Sheep or goats - up to 40 animals per watering space	.25 per space	(0.5 per space)
Laying hens - up to 200 birds per 4-ft. trough waterer (90°F)	.12 per waterer	(0.25 per waterer)

Broilers - up to 100 birds per 4-ft. trough waterer (100°F)	.12 per waterer	(0.25 per waterer)
Turkeys - up to 50 birds per fountain or per 4-ft. trough	.2 per fountain	(0.4 per fount)
Watering tank, open - for cattle, sheep & horses	2.5 per tank	(5.0 per tank)

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*From USDA and Midwest Plan Service recommendations.

**Some irrigation sprinklers have more water capacity than shown in this table. If the capacity of your sprinkler is known, and it is greater than 5 gallons per minute, substitute that figure in place of 5 in the second column and 1/2 of that amount in the 1st column.

ANSWER SHEET

LIVESTOCK WASTE MANAGEMENT
ASSIGNMENT SHEET

PART 1: DAILY WATER NEEDS

Step 1:
200 x 15 = 3,000
150 x 7 = 1,050
400 x 4 = 1,600
12 x 10 = 120

Maximum water needs 5,770 gallons per day

PART 3: YOUR PROBLEMS

Problem 1:
200 x 450 = 90,000 sq. ft.
90,000 x (20 x .4) = 720,000 cu. ft.
7.5 x 720,000 = 5.400,000 gallons

Problem 2:
55 x 150 = 8,250 sq. ft.
8,250 x 15 = 123,750 cu. ft.
7.5 x 123,750 = 928,125 gallons

PART 4: WATER PEAK DEMAND

Cows - 3 tanks at 2.5 gpm per tank	7.5 gpm	
Calves - 150 ÷ 40 = 4 waterers at .75 gpm	3.0 gpm	
Hogs - 400 ÷ 10 = 40 spaces at .25 gpm	10.0 gpm	Use column 2 = 20 gpm value of .5 gpm
Hose for cleaning floor, flush tank 5 gpm	5.0 gpm	
	35.5 gpm needed	

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 1 - What is waste disposal?

Objective: Upon the conclusion of the lesson, students will be able to define and characterize waste disposal systems.

Study Questions:

1. What are nature's and society's solutions to waste problems? And what are the effects of these problems?
2. What are the principles of a waste system?
3. How do you decide on a system?
4. What regulations relate to waste management?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 1 - What is waste disposal?

TEACHING PROCEDURE

A. Review

B. Motivation: Visit a local farm with a slotted floor, storage, and lagoon. Ask how much manure an animal can produce a day. How long does it have to stay in a lagoon before it can be discharged?

C. Assignment

D. Supervised Study

E. Discussion

1. List the problems on the board that are encountered by a large livestock facility and have the class try to formulate some solutions based on past knowledge.

   What are nature's and society's solutions to waste problems? And what are the effects of these problems?

   1) Nature's solutions avoid problems naturally.
      a) Balance of nature is based on zero-waste systems. Everything is used.
      b) Big cats, scavengers, microbes, and insects eat bugs.
      c) When population loses or exceeds food supply, population is reduced.
   2) Society's problems and solutions are not new.
      a) Past problems were acted upon within the natural environment; population was not overly affected.
      b) The first flushing system was instigated by Hercules flushing manure by shifting the course of a river.
      c) Nomadics spread manure naturally. Manure conservation and reuse was practiced by early Chinese.
      d) Slotted floors go back 200 years in Iceland.
      e) Dairy barn manure problems date back to the 19th Century. Large poultry manure dates back decades.
   3) Size and effect on nature is a new problem.
      a) There is a widespread public awareness of overloading.
      b) Public is concerned over "dying" lakes and the ignorance of the waste problem in swine producers.

c) Growth of problems in waste management is not as sudden as growth of public concern.
d) Trends have increased the concentrations of livestock.

2. The selection of a workable system is a complex operation that needs to be dovetailed between agents of the EPA, SCS, building engineers, and the producer. Have an EPA representative talk to the class about pollution problems.

What are the principles of a waste system?

1) Any system starts with a source of wastes.
2) Almost all systems end in the soil.
3) All systems are compromises between investment, labor, convenience, and aesthetics.
4) No system is "best". Select the best system for your individual needs.

3. The decision you make in your program must be approved by all environmental agencies concerned. Have a sample system available for study.

How do you decide on a system?

1) Look objectively at where you are, where you want to be, and ways to get there.
2) Identify sources of wastes.
3) Consider waste handling alternatives and disposal alternatives.
4) Look at outside influences such as neighbors, flood areas, etc.
5) Major factors
    a) Operation
    b) Farm
    c) Climate
    d) Animal
    e) Regulations
    f) Proximity of neighbors

4. Get a listing of rules and regulations for installing a waste management system in your area. Put the definition of pollution on the board. "A pollutant is a resource out of place." Discuss possible pollutants.

What regulations relate to waste management?

1) Federal, state, and local regulations control air, water, and noise pollution.
2) Federal regulations require permits if size of water problem is large.

3) All new construction feed lots must prevent polluted runoff from a 25-year, 24-hour rainfall.
4) Also, the control facility must contain space for maximum expected volumes of runoff or treated manure generated during normal operation.
5) By July 1, 1983, all enterprises must meet requirements
6) If diversion, water (unpolluted runoff /rain/) can overflow a system. Increase design capacity.
7) A state can impose additional or more stringent requirements.
8) Zoning laws and public health laws may affect dairy units, such as distances between buildings and people.
9) Consult with an Extension Agricultural Engineer.

F. Summary

Consult all the agencies that use the waste management regulations. These agencies can cause difficulty if not consulted before construction begins.

G. Evaluation

Answers to Exam

1. F
2. T
3. T
4. F
5. A resource out of place

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 1 - What is waste disposal?

EXAM

T F 1. Slotted floors are a new innovation that has revolutionized the industry.

T F 2. Trends in livestock have been toward increasing the concentration of livestock.

T F 3. The area's topography is an important factor when planning a system.

T F 4. Farms are exempt from zoning laws because of their importance to society.

5. Define pollutant.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 2 - What are the characteristics of animal wastes?

Objective: Upon the conclusion of the lesson, students will be able to identify different groups of waste and to identify the hazards of these wastes.

Study Questions:

1. What is animal waste?
2. What are the characteristics of manure and bedding?
3. How is manure properly diluted?
4. What special characteristics are in dairy wastes?
5. How is runoff from lots controlled?
6. What are the problems associated with the gases and odors of stored waste?
7. How are noxious gases controlled?
8. How are manure odors controlled?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 2 - What are the characteristics of animal wastes?

TEACHING PROCEDURE

A. Review

B. Motivation: Bring in samples of different types of manure (beef, swine, poultry) and types of waste (bedding, hair). Discuss the characteristics of each.

C. Assignment

D. Supervised Study: List and compare the quantities of waste produced by each animal.

E. Discussion

1. List the components of animal waste on the board and see if the class can add any others.

   What is animal waste?

   1) Manure refers to feces and urine.
   2) Waste is manure plus bedding, rain, runoff, hair, feather, and debris.
   3) Properties of waste depend on the species.
   4) Manure with up to 15% solids is semi-liquid slurry.
   5) Manure with 4% or less solids can be handled as a liquid.

2. Using samples of manure and bedding, show the characteristics of both.

   What are the characteristics of manure and bedding?

   1) Tables II to IV of the text list the properties of manure.
   2) Table V lists common types of bedding.
   3) To estimate weight of bedding, use total weight equals weight of manure and weight of bedding.
   4) To estimate volume of manure and bedding, use total volume equals volume of manure and one-half volume of bedding.
   5) Bedding can be added to manure to make it easier to handle as a solid (Figure 1).

3. Mixing water with manure is a common practice to make the manure easier to handle. Control the source of water carefully to avoid extra cost from purchasing water.

How is manure properly diluted?

1) To calculate water flow from a nozzle, the gallons per minute equals gallons filled times 60 seconds required.
2) Dilute Table VI shows water needed per cubic foot of manure to change moisture content.

   Example: Eight pounds of water (nearly 1 gallon) added to 10 pounds of waste at 80% moisture dilutes to 89% moisture.

4. The quantity of water in a dairy facility is much higher than other operations. Ask the students why.

What special characteristics are in dairy wastes?

1) Volume is much higher due to washing of udders. A cow can use 9 gallons of water per day for washing udders.
2) Clean up with a high pressure hose twice a day.
3) A 100-cow unit with automatic washing uses over 800 gallons per day, or 3,200 cubic feet per month.
4) Milking plant waste water contains several characteristics.
   a) Milking plant waste water resembles dilute liquid manure.
   b) Suspended solids do not settle easily.
   c) Milking plant waste water contains colostrum and milk solids.
   d) Milking plant waste water contains large volumes of cleaning water and cleaning substances.
5) Milk solids do not settle and can cause bad odors in an anaerobic lagoon.

5. The runoff carries the solids to the storage or disposal facilities and must be properly controlled. Set up a dirt and paved lot in a 10-inch by 12-inch metal pan. Pour water from the top with the pan at an angle and look at the runoff. Dirty the surfaces and repeat the process.

How is runoff from lots controlled?

1) Runoff transports manure, soil, chemicals, and debris.
2) "Lot" means any outdoor animal area.
3) Runoff from unpaved lots is affected by slope and intensity of rainfall.
   a) Lightly scrape unpaved lots.
   b) Direct other water sources away from lots.

    - c) Light scraping increases water-holding ability.
    - d) When snow melts it is more damaging than rain.
- 4) Remove solids by runoff.
    - a) Drainage increases by increasing slope and decreasing slope length.
    - b) Manure mulching to decrease runoff causes odor problems.
    - c) Using settling channels shows accumulations of 2 cubic yards (about 2 tons) of solids per head per year in a lot with a 15° slope 340 feet long.
- 5) Scrape only surface; avoid disturbing lower 3 inches to 4 inches.
- 6) Liquid runoff is determined by the drainage area. In storm rainfall, P is inches of precipitation. Rule of thumb is that runoff is equal to .7P inches.
- 7) Paved lots should be scraped regularly.
- 8) Design facilities for runoff.

6. Have the students describe the types of smells found around feed lots and how dangerous they are to humans.

What are the problems associated with the gases and odors of stored waste?

1) Noxious gases from manure can be harmful and even lethal.
2) The noxious gas (NG) carbon dioxide is not toxic but can contribute to asphyxiation. At 25% of total air death produced through respiration, the normal concentration of carbon dioxide is .03%.
3) The noxious gas ammonia is explosive when there is a mixture of 16% of it in the air. It is water soluble so there is more smell with bedding. Suffocation can be caused by a .05% mixture. Loss of appetite, sneezing, and salivation can be caused by a .02% mixture. If condensed and oxidized, it can become poisonous.
4) The noxious gas hydrogen sulfide is the most toxic gas associated with liquid manure storage. It is flammable and explosively lethal at 1,000 ppm (.1%). When agitation occurs, more hydrogen sulfide is released; 20 ppm causes fear of light, nervousness, and appetite loss.
5) The noxious gas methane is highly flammable, explosive at 5% concentration, lighter than air, and not highly toxic. The problem lies in explosiveness.

7. Control of these pit gases to prevent their production and accumulation is important.

How are noxious gases controlled?

1) Clean solid floors daily.
2) Keep litter or bedding dry.
3) Do not overfill pits.
4) Add water to keep solids submerged.
5) When solids under slotted floors are dried with forced air, vent heat and carbon dioxide outside.
6) Vent pit gases outside.
7) Have standby generator to keep ventilation working in case of power failure.
8) Install power failure alarm.
9) Vent heater and engine exhausts outdoors.
10) If oxidation ditch is used and running, ventilate.
11) Maintain pit level at near neutral to control odors.
12) On cold nights with minimum ventilation, use air circulating fans to improve mixing the inside air.

8. Brainstorm different methods of controlling odors in the confinement building. Have different odor reducers on hand.

How are manure odors controlled?

1) Odor quality is a comparison with a known odor.
2) Strength is the amount of fresh air needed to dilute odorous air.
3) Occurrence includes frequency and total length of time odor persists.
4) Some odors are water soluble.
5) Ventilation dilutes odors.
6) Aerate by aerobic lagoons or oxidation ditches.
7) Cover the storage pit or incorporate wastes into the soil.
8) Burn the gases to remove organic products.
9) Absorb most gases with activated carbon filters.
10) Mask odors with a pleasant one.
11) Filter dust particles.
12) Chemical treatment may be hydrated lime which not only reduces hydrogen sulfide and carbon dioxide but also releases ammonia to lower fertilizer value. Chlorine stops bacteria action, which stops odors and treatment.

F. Summary

Animal wastes are characterized by the properties they contribute to the runoff from the farm. Manure is the sought after portion of animal wastes because of the nutrients found in the feces and urine. The bedding and hair are less usable and must be disposed of separately. The main concerns of animal wastes are environmental. The poisonous nature of the gases they produce can explode or suffocate livestock.

G. Evaluation

Answers to Exam

1. T
2. F
3. F
4. F
5. T
6. Any three of the following:
    a. Clean solid floors daily.
    b. Keep litter or bedding dry.
    c. Do not overfill pits.
    d. Add water to keep solids submerged.
    e. Vent heat and carbon dioxide outside.
    f. Vent pit gases outside.
    g. Have standby generator in case of power failure.
    h. Install power failure alarm.
    i. Vent heater and engine exhausts outdoors.
    j. If oxidation ditch is used and running, ventilate.
    k. Maintain pit level at near neutral to control odors.
    l. Use air circulating fans to improve mixing the inside air.
7. Any two of the following:
    a. Odor quality is a comparison with a known odor.
    b. Strength is the amount of fresh air needed to dilute odorous air.
    c. Occurrence includes frequency and total length of time odor persists.
    d. Some odors are water soluble.
    e. Ventilation dilutes odors.
    f. Aerate by aerobic lagoons or oxidation ditches.
    g. Cover the storage pit or incorporate wastes into the soil.
    h. Burn the gases to remove organic products.
    i. Absorb most gases with activated carbon filters.
    j. Mask odors with a pleasant one.
    k. Filter dust particles.
    l. Chemical treatment may be hydrated lime.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 2 - What are the characteristics of animal waste?

EXAM

T F 1. Animal waste consists of feces, urine, bedding, and rain.

T F 2. When wastes are up to 4% solids, the manure slurry is solid.

T F 3. Milk solids are easily decomposed in a lagoon anaerobically.

T F 4. Manure mulching is the best method for reducing runoff.

T F 5. Methane is dangerous because it is lighter than air and highly flammable.

6. List three methods for controlling noxious gases.

   a.

   b.

   c.

7. List two methods for controlling manure odors.

   a.

   b.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 3 - How are livestock wastes collected on the farm?

Objective: Upon the conclusion of the lesson, students will be able to select a collection system by considering the type of facility, labor requirements, investment, and total waste handling system.

Study Questions:

1. How do slotted floors affect a collection system?
2. What other types of floors are used?
3. What types of scrapers and blades are available for collection systems?
4. What is the use of a front-end loader for manure collection?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 3 - How are livestock wastes collected on the farm?

TEACHING PROCEDURE

A. Review types of waste.

B. Motivation: How many collection systems can the students name? What types of scrapers are used in the area? How well do these systems work?

C. Assignment

D. Supervised Study: Design a manure removal and collection system for an area feed lot and dairy or confinement building.

E. Discussion

1. If possible, the class should visit a local confinement operation to see the floor types--especially slotted floors.

   How do slotted floors affect a collection system?

   1) Slotted floors should provide rapid separation of an animal from its manure.
   2) Look at the size of openings in respect to animal slippage and foot injury.
   3) When selecting slats consider:
      a) Initial cost
      b) Predicted life
      c) Intensity of use
      d) Strength
      e) Corrosion
      f) Fire
      g) Noise
      h) Replacement cost
      i) Stability: twisting, flexing, pinching
   4) Tapered slats pass waste better than uniform-width slats.
   5) Space slats 1/2 inch to 1 inch apart and 2 inches to 3 inches from walls.
   6) Types of slats are shown in Figure 3 of your text.
      a) Reinforced concrete
      b) Wood
      c) Punched or perforated plastic or steel
      d) Expanded metal
      e) Extruded aluminum, fiberglass, or plastic
      f) Steel or aluminum bars
      g) Reinforced concrete gang slats

7) Research has set guidelines to maintain clean floors in partly slotted pens.
    a) One-third of the total area is slotted.
    b) Solid partitions have a solid floor. Open partitions have an open floor.
    c) Water animals over slats; feed animals over solid floor.
    d) Keep pens full.
    e) Slope floors toward slots.

8) Slat design is based on pounds per linear foot (plf) and pounds per square foot (psf).

9) Use wood slats for smaller animals. Oak, elm, hickory, or maple slats last three to five years.

10) Concrete slats
    a) Concrete slats last for years and are effective.
    b) Concrete slats can be precast or cast in place.
    c) Air entrained 7 1/2 bag mix should form slats with no more than 2-inch to 3-inch slump. The maximum aggregate size should be 1/2 inch to 3/4 inch. The 28-day's strength of concrete should be at least 3,500 pounds per square inch.
    d) Crown slats for better drainage.
    e) Pipe can be included inside slats.

11) Steel slatted flooring is made of corrosion-resistant steel, epoxy, and porcelain enamel-coated steel. This flooring is for smaller animals. The openings are usually diamond shaped.

12) Aluminum slats are lightweight, easy to handle and transport, and can be noisy and need insulating from steel equipment to prevent corrosion.

13) Plastic slats of polyvinylchloride (PVC) are lightweight, non-corrosive, long wearing, and easy to replace.

14) Fiberglass reinforced plastic (FRP) is stronger than PVC but can be slippery.

2. Although slats are very popular, other floor types are available for use. Have the students describe different systems.

What other types of floors are used?

1) Grates of steel straps 1 inch to 1 1/2 inches wide and 3/16 inch to 1/4 inch thick are used. Smaller animals need grates of steel straps 3/8 inch to 3/4 inch wide.

2) Removable steel grates of smooth round rods are best for the gutter behind dairy cows.
3) Sloped concrete floors assist movement of manure and should have slopes of 1/2 inch per foot (4%) or more to 1 inch per foot (8 1/2%).
4) Sloped concrete floors are usually 4 inches thick on a good base to 6 inches thick for movement of heavy machinery.
5) Reinforce concrete floors with 6 inch by 6 inch welded wire mesh for added vertical displacement resistance.

3. Popular methods for cleaning lots and floors are scrapers and blades. Draw on the board different systems available.

What types of scrapers and blades are available for collection systems?

1) Main advantage is labor reduction.
2) Scrapers and blades are used on solid floors or under slotted floors in gutters, channels, or troughs.
3) Cold weather problems are handled by frequent or continuous scraping.
4) In warm weather, scrape once or twice a day.
5) Scrapers used in animal areas need to move at under 5 feet per minute.
6) Scrapers are usually pulled by a chain or cable in one direction. Two-way systems are available.
7) Shuttle type scrapers move in short strokes with a hinged blade to force manure in one direction.
8) Tractor mounted blades are popular in large open areas.

4. Ask the students: "What are the problems associated with using a front-end loader to move manure?" List on the board.

What is the use of a front-end loader for manure collection?

1) A front-end loader is used to remove solid manure from open lots, storages, or building floors.
2) Size varies in a front-end loader, usually 1,000 to 4,000 pound capacity.
3) A front-end loader needs a large turning radius, limiting its used to straight runs.
4) It reduces traction on rear wheels. It needs proper front wheel spacing.
5) Use of self-propelled loaders (skid-steer) is popular.

6) Large units are available but have a high initial cost.

F. Summary

Collection methods must be considered during the design phase of the farm plan. Systems that require low labor and maintenance need special consideration.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. F
5. F

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 3 - How are livestock wastes collected on the farm?

EXAM

T F 1. The openings in the slats are of no concern when large animals are housed in confinement.

T F 2. Tapered slats are advantageous because they allow manure to pass through more freely.

T F 3. Reinforced concrete slats are only important in finishing and gestation houses where weights are highest. Straight cast slats can be used in the nursery and farrowing house.

T F 4. Sloping the floor up to 1 1/2 inches per foot is safe for most animals.

T F 5. Front-end loaders are the best system for removing manure from all feeding areas.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 4 - How is runoff collected on the farm?

Objective: Upon the conclusion of the lesson, students will be able to calculate runoff flow, list methods of collection, and select the system to be used in different circumstances.

Study Questions:

1. What are the types of runoff?
2. How is the fluid flow in open channels calculated?
3. What collection method is used for small areas?
4. How is the size of open concrete and earth channels determined?
5. What are the capacities of waste pipe?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 4 - How is runoff collected on the farm?

TEACHING PROCEDURE

A. Review

B. Motivation: How is the runoff from the roof collected and carried away? How is runoff from a field controlled? What different methods are available to channel the runoff?

C. Assignment: Locate a runoff channel and calculate the possible flow at maximum capacity.

D. Supervised Study

E. Discussion

1. What is runoff? Where does it come from and how does it act? (See Figure 8 in your text.)

   What are the types of runoff?

   1) Lot runoff is from rain or melted snow and contains animal manure. It must be handled by a waste management system.
   2) Clean runoff does not contain any manure and is diverted from the waste management system.
   3) Curbs, dikes, and terraces stop flow from slopes.
   4) Channels and pipes transport water.

2. Develop flow problems for the students to calculate in class or at home. Include several shapes of open channels.

   How is the fluid flow in open channels calculated?

   1) Manning's formula to find channel capacity is in cubic feet per second.
      a) Q,cfs equals (1.486) ($S^{.5}$) ($A^{1.667}$) divided by ($N \times P^{.667}$).
      b) S equals slope, feet per feet, inch per inch, etc.
      c) A equals water cross sectional area in square feet.
      d) N equals coefficient for surface roughness. See Table XVI on page 25 of your text.
      e) P equals wetted perimeter in feet.
   2) The simpler method of interpreting Manning's formula is to use Figure 9 on page 24 of your text.

3) The velocity of water affects settling and erosion.
    a) There is no settling if velocity is above 1 1/2 feet per second.

    NOTE: This section is for advanced students and can be confusing for students under the 11th grade level.

3. Drainage from buildings is an important concern. Discuss methods of controlling roof water.

What collection methods are used for small areas?

1) Designs for roof runoff are based on 10-year, 5 minute peak rainfall in inches per hour and surface area drained in square feet.
2) Divert the water away from the waste control system.
    a) Design gutters to carry all water to the ends of the building.
    b) Design small gutters to be carried away underground.
    c) If open channel can be used, let water fall from the eaves.
    d) Use Table XVII on page 26 of your text.
3) Large gutters need large downspouts. Table XVIII on page 26 lists sizes of downspouts. Rectangular spouts of the area of the gutter will carry all waste needed. Round downspouts are tabled in Figure 11, page 26.

4. Have the class discuss the advantages and disadvantages of different channels. Primarily concrete and earth types should be studied.

How is the size of open concrete and earth channels determined?

1) To determine the capacity of a concrete channel, the width and depth are needed. (See Table XIX on page 27 of your reference.)
2) When the sides are sloped out, concrete channels will have an increased capacity.
3) Clean runoff earth channels are grassed and trapezoidal in shape. (See Table XXI--Capacities--on page 28 of your text.)
4) Low slope channels can be used for settling solids.

5. Ask the students if they have put in any pipe for drainage or a lagoon. How much can the pipe carry?

What are the capacities of waste pipe?

1) Low pressure pipes are used to transfer liquid wastes from pits to lagoon, often by gravity.
2) Capacities of the waste pipe will depend on the type of pipe.
    a) Tile pipe is one type. See Table 12a on page 17 of your text.
    b) Corrugated tubing is another type. See Table 12b on page 17 of your text.
3) The slope of the pipe is determined by the rate of flow. It is also determined by whether or not the end of the pipe is submerged.
4) Slope of pipe is based on levels of the two holding units.
5) Culvert capacities (Figure 13 on page 30 of your text) are determined by water depth, culvert length, diameter of pipe, and whether or not the end of the pipe is submerged.

F. Summary

Runoff from the farm must be controlled to prevent both surface erosion and pollution from livestock areas. The key to good runoff control is preplanning. The system should be designed and sized to each individual farm.

G. Evaluation

Answers to Exam

1. F
2. T
3. T
4. T
5. F

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 4 - How is runoff collected on the farm?

EXAM

T F 1. Lot runoff and clean runoff should be treated as equals and all pass through the waste system.

T F 2. Fluid flow is calculated by the Manning Formula.

T F 3. Roof gutters are necessary to collect and divert water flow from roofs and the waste system.

T F 4. Channel capacity is based on the width and depth of the channel.

T F 5. At full capacity, the rate of flow of water in a culvert will increase with the slope of the culvert.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 5 - How are gutters flushed?

Objective: Upon the conclusion of the lesson, students will be able to identify flushing devices and to identify the two designs of flushing devices.

Study Questions:

1. How are gutters flushed?
2. What flushing devices are available?
3. What are the two design methods for flushing?
4. What are flushing flumes?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 5 - How are gutters flushed?

TEACHING PROCEDURE

A. Review

B. Motivation: Who has seen a flushing system for waste control? How does the system work? Do you think it does a good job?

C. Assignment

D. Supervised Study: Optional: Design a flushing system as a group in class.

E. Discussion

1. Hydraulic flushing increases the amount of materials handled by 10% to 100%. Ask the class why this is so and ask about the labor it helps to replace.

   How are gutters flushed?

   1) Increased use of flushing will increase storage needs in the lagoon.
   2) The larger the surface area over which the manure is spread, the larger the increase in the quantity of water and difficulty of flushing.
   3) A flushing velocity of 3 fps will remove fresh manure.
   4) To transport dislodged manure, a flow of 2 fps is needed.
   5) The stream of water must equal the height of pile of manure encountered.
   6) Limit flushing channels to 18 inches to 24 inches wide.
   7) Flushing frequency is determined by surface wetting, "toilet" training, and prevention of odors. Every 2 hours may be an average flushing frequency.
   8) Flush manure every 1/2 hour under poultry; flush manure once a day for most livestock.

2. An automatic system for flushing will save time and cleanup but must be carefully planned before designing the structure. List the three systems on the board and try to find advantages and disadvantages of each system.

   What flushing devices are available?

1) The dosing siphon is an automatic device for emptying a tank intermittently into a flushing channel.
   a) It fills slowly.
   b) When the level needed is reached, water flows quickly out and is discharged.
2) The tipping bucket is simple, almost maintenance free, slow to fill, and rapid to discharge.
   a) The tipping bucket can handle a large area at once.
   b) Capacities can be changed.
   c) Select a tipping bucket that can rotate 360°.
3) The trap door tank fills until a floor level door opens. It has the advantages of both a stationary tank and wide channel discharge.

3. There are two basic designs to consider when planning the flushing system. They are discussed here simply but can be expanded if detailed work is necessary.

What are the two design methods for flushing?

1) Simple hydraulic design
   a) Simple hydraulic design provides uniform channels.
   b) Simple hydraulic design provides frequent flushing.
   c) Few wastes are removed per flush in the simple hydraulic design.
   d) Simple hydraulic design necessitates a relatively high water requirement.
2) Modified hydraulic design
   a) Modified hydraulic design furnishes variable-width gutters.
   b) Modified hydraulic design furnishes variable-slope gutters.
   c) Less frequent flushing is required.
   d) More wastes are removed per flush.
   e) Lower water usage is an advantage.

4. What are the problems with flushing flumes in a waste system? How are they designed and installed?

What are flushing flumes?

1) Flumes are under floor channels to carry manure out of buildings.
2) Flume flushing power is based on the diameter of the channel, slope of the channel, and amount of water.

3) The flume resembles a pipe set under a floor with a top slot for manure to enter. Less water actually contacts the animal.

F. Summary

Careful planning of a flushing system will cut labor costs and odors but increase the amount of liquids flowing into the lagoon. Try pumping water from lagoon to flush tanks as water costs are high.

G. Evaluation

Answers to Exam

1. T
2. F
3. a. Dosing siphon
   b. Tipping bucket
   c. Trap door tank

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 5 - How are gutters flushed?

EXAM

T F 1. Hydraulic flushing can increase the amount of material handled by 100%.

T F 2. To remove fresh manure, a flow of 1 fps is needed in the flushing system.

3. List the three flushing devices available.

a.

b.

c.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 6 - What storage methods are available for animal waste?

Objective: Upon the conclusion of the lesson, students will be able to list the criteria for storage units, list the types of storage units, and outline the needs of a storage system.

Study Questions:

1. What factors affect the location of a storage unit?
2. What criteria are needed when planning below-ground storage tanks?
3. How are earth liquid and slimy storage units designed?
4. What is the function of a holding pond?
5. How is the size of solid manure storage calculated and the storage unit constructed?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 6 - What storage methods are available for animal waste?

TEACHING PROCEDURE

A. Review

B. Motivation: How many types of manure storage can you name? Did you see any problems with them? Of what were they made?

C. Assignment

D. Supervised Study: In class design a storage system from the pit to the storage unit for different volumes of waste.

E. Discussion

1. How do you decide where to put a storage unit? What factors do you have to consider?

   What factors affect the location of a storage unit?

   1) Pollution controls and requirements or guidelines for the minimum size of waste storage must be considered.
   2) Avoid locating on creviced bed-rock or below water table; watch for groundwater pollution.
   3) Allow 100 feet between the water supply and storage.
   4) Watch the prevailing winds; smell travels.
   5) Storage unit must be convenient for filling and emptying.
   6) Control of surface water is a factor affecting the location of a storage unit.

2. There are three types of storage tanks: shallow, large, and covered tanks. Each has its own design considerations.

   What criteria are needed when planning below-ground storage tanks?

   1) Specific design criteria include:
      a) Management practices
      b) Safety features and practices
      c) Structural and functional adequacy
   2) Storage capacity is regulated by:
      a) Number and size of animals
      b) Amount of waste
      c) Runoff stored
      d) Frequency of emptying storage unit

3) Filling liquid manure storages
   a) First, add 3 inches to 4 inches of water to pits.
   b) Lower fly reproduction by covering openings and keeping solids submerged.
   c) Keep wastes wet.
   d) Use high pressure water for floor flushing--100 psi using 5 to 10 gpm.
   e) Watch for debris that may foul pumps.
   f) Dilute wastes to 90%.
4) Ventilate manure storages; exhaust the air.
   a) Use a gas trap in the line.
   b) Provide an alarm system for power failures.
5) Maintenance check for leaks and deterioration of metals.
6) Shallow tanks are normally in a building, usually 3 feet to 4 feet wide and 4 feet to 5 feet deep.
7) Deep tanks need regulatory agency approval.
   a) Cast-in-place concrete is recommended.
   b) Insulate and waterproof deep tanks.
   c) Add water to counteract uplift pressure in lines with high water tables.
   d) Protect openings with grills or covers to prevent injury.

3. A popular method of manure storage is an earth-walled unit because of the lower costs of construction.

How are earth liquid and slimy storage units designed?

1) Design includes liquid manure inlets.
   a) Liquid manure inlets discharge near the center of storage.
   b) Below surface inlets require pressure.
   c) Above surface pipes may freeze and plug. Batch loading works best.
   d) Open trench (concrete) is easily cleaned, but there may be problems of freezing and odors.
   e) Cleanouts should not be spaced more than 300 feet apart.
2) Emergency spillways are 1 foot to 2 feet below the top of the dam to catch basin or disposal field.
3) Lagoon must be built to hold a 25-year, 24-hour rain design.
4) A trickle tube handles overflow but output must be controlled. Cleanouts are needed to correct clogging.
5) In two-stage lagoons, pipe between lagoons must be able to handle overflow easily.
6) Undiluted wastes (15% solids) must be agitated before pumping for transport.
7) Access by ramp should be no steeper than a ratio of 10:1.

4. Runoff water is stored temporarily in a holding pond for about 180 days, depending on local regulations.

   What is the function of a holding pond?

   1) Bottoms and sides should be watertight.
   2) A holding pond receives drainage from lot, after it has been through a settling basin, or drainage from lagoon overflow.
   3) A holding pond does not receive roof water.
   4) Banks of earth dams are no steeper than a ratio of 2 1/2:1.
   5) Empty when waste will infiltrate soil.
   6) Capacity of a holding pond is based on:
      a) Duration of storage
      b) Source of liquids
      c) Amount of liquids
      d) Proportion of rainfall
      e) Relative rainfall and evaporation during storage
      f) Volume of solids
      g) Volume required for lagoon treatment
   7) Lot runoff is calculated by characteristics of manure, weather data, and anticipated management practices.
   8) Lot runoff solids are an equivalent of a 1/2-inch layer of solids.
   9) Sludge build-up can be controlled by paving.
   10) Net rain is estimated from weather data.
   11) Five factors used to calculate total capacity
      a) Runoff
      b) Runoff solids
      c) Other liquid sources
      d) Sludge build-up
      e) Net rain
      f) Use Table XXVI on page 45 of your text.
   12) Capacity
      a) Top area = WL (Width X Length).
      b) Bottom area = (W - 2DS) X (L - 2DS). (DS = Distance Slope.)
      c) Volume = $(WLD - SD^2) \times (L + W) + \frac{4S^2D^3}{3}$.
         (D = Depth; S = Slope.)

5. What are different ways to store solid manure? How is it transported? How is it disposed? Look on pages 48 to 49 of your text for examples.

   How is the size of solid manure storage areas calculated and the unit constructed?

   1) Size is important for convenience, saving maximum fertility, preventing water pollution, and avoiding the spreading of manure in bad weather.

2) Up to 180 days of storage is recommended.
3) Size is determined by:
    a) Number and type of storage facilities
    b) Type of manure
    c) Bedding amount
    d) Number of animals
    e) Number of days of storage needed
4) Construction suggestions:
    a) Slope floor to one or both sides toward drains.
    b) Provide floor drains. Slope floor toward drains 2%. Use screens or grills.
    c) Provide gutter for runoff.
    d) Start stacking at high end.
5) Provide convenient access for equipment with a low slope (20:1 ratio is preferred) to prevent tipping problems with front-end loaders.
6) Walls, floors, and ramps (concrete) recommended are:
    a) Five-inch floor over 6 inches gravel or crushed rock
    b) Four-inch floor over 4 mil plastic over gravel
    c) Two-inch sand can replace gravel over compact soils.

F. Summary

Selection of a storage system is the most difficult part of the disposal system. There is a tendency for the builder to underestimate or fail to plan for future development. Plan carefully.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. F
5. a. Management and practice
    b. Safety practices and features
    c. Structural and functional adequacy
6. a. Convenience
    b. Saving maximum fertility
    c. Preventing water pollution
    d. Spreading manure in bad weather

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 6 - What storage methods are available for animal waste?

EXAM

T F 1. The storage facility should be located near (within 50 feet) of a water source to make cleaning easier.

T F 2. Deep storage tanks require the approval of local regulatory agencies.

T F 3. The only problem with above-ground inlet pipes is the high cost.

T F 4. Rainfall is diverted from the holding ponds so it is not included in the size calculations.

5. Name the three design criteria for below-ground storage tanks.

a.

b.

c.

6. Two considerations when planning the size of a solid manure holding area are:

a.

b.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 7 - How are the solids and liquids separated?

Objective: Upon the conclusion of the lesson, students will be able to separate solids and liquids using settling, screening, and evaporation techniques.

Study Questions:

1. What methods are available to separate solids and liquids?
2. How is a settling system designed?
3. What are the different settling systems?
4. What is a screening system?
5. How is evaporation used to separate solids and liquids?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 7 - How are the solids and liquids separated?

TEACHING PROCEDURE

A. Review

B. Motivation: What is a settling basin? Are they used in this area? What are their advantages and disadvantages? How does it help to control pollution?

C. Assignment

D. Supervised Study: Do an in-class design for a settling basin for various size operations.

E. Discussion

1. There is an advantage to handling solids and liquids separately for irrigation systems. What advantages can the class list? Put these on the board and discuss them.

   What methods are available to separate solids and liquids?

   1) Settling by reduced velocity and detention
   2) Screening solids
   3) Evaporating which reduces total volume

2. Settling removes solids by slowing the flow of the the liquids, letting the heavier particles sink to the bottom. To demonstrate this principle, mix some grain and sand in water and pour down a runway into a plastic tray cutting the flow rate. After the water is drained off, check for settling.

   How is a settling system designed?

   1) A settling tank, usually of concrete for short-term storage, is normally full of liquids with manure in a slurry.
   2) Rules of thumb for design
      a) There should be one linear foot of outlet per 110 cubic feet per hour for loading a settling system.
      b) There should be one square foot of settling area per 4 cubic feet of manure per hour for loading a settling system.
      c) To calculate flow rate:

$$\text{Cubic feet per hour} = \text{inches per hour of rainfall} \times \frac{\text{square feet of runoff area}}{\text{12 inches per hour}}$$

d) To find length of outlet weir:

$$\text{Feet} = \frac{\text{flow rate}}{110}$$

e) To find surface area:

$$\text{Square feet} = \frac{\text{flow rate}}{4}$$

f) To find length of tank:

$$\text{Feet} = \frac{\text{surface area}}{\text{outlet weir length}}$$

g) To find volume:

$$\text{Cubic feet} = \text{depth} \times \text{area}$$

or

$$\text{Cubic feet} = \text{depth} \times \frac{\text{flow rate}}{4}$$

h) To find detention time:

$$\text{Hour} = \frac{\text{volume}}{\text{flow rate}}$$

or

$$\text{Hour} = \frac{\text{depth}}{4}$$

3) In settling solids from lot runoff, the most critical factor is rainfall. The biggest problem is removing solid manure.
4) A settling basin is usually a broad earth-walled area accessible by tractor for cleaning and loading.
5) A properly maintained basin will trap 85% of the solids.
6) A ratio of 3:1 slope on sides should be maintained.
7) A porous wall on the down side will aid in settling solids before passing them to the next stage.
8) Perforated pipe should be located in the lower corner to remove solids.
9) Porous dams can work well as a strainer of easily cleaned manures.
10) Settling channel is a low slope terraced, flat bottomed waterway to settle manure.
11) Design factors
    a) Three to 1 ratio side slope
    b) Two fps flow first 50 feet to 100 feet
    c) Five-tenths fps flow next 100 feet to 300 feet

4. Screening can be done by several methods other than the mechanical method. List these on the board--grass, filters, and wire screens--and discuss them.

   What is a screening system?

   1) The screening process
      a) Removes large particles
      b) Lowers biological oxygen demand
      c) Becomes easier to treat biologically
      d) Pumps more easily
   2) Grass can be used as a natural filter.
      a) Only lightly loaded slurries should be applied.
      b) It is hard to remove solids from grass.
      c) Overloading kills grass.

5. When space permits and the weather cooperates, evaporation can be used to separate solids and liquids.

   How is evaporation used to separate solids and liquids?

   1) Where evaporation exceeds precipitation, evaporation ponds can be used.
   2) A dehydrator can be used, but it has problems.
      a) High initial investment
      b) Mechanical problems
      c) High energy requirements
      d) Unpleasant odors
      e) Severe corrosion of dryer parts
      f) High power demand
   3) Evaporator wastes are difficult to merchandise.
   4) Check local laws for dryer regulations.

F. Summary

A key to successful manure control is the separation of the solids and liquids. For irrigation purposes the liquids need to be separated early so that the nutrient enriched water can quickly be pumped to the crops. Care must be taken to eliminate the high corrosiveness of manure on metal equipment; therefore, frequent cleaning is a problem related to separation.

G. Evaluation

Answers to Exam

1. T
2. F
3. T
4. a. Settling
   b. Screening
   c. Evaporation

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 7 - How are the solids and liquids separated?

EXAM

T F 1. If properly constructed, a settling basin will trap 85% of all solids.

T F 2. A 6:1 ratio slope is recommended for settling basins because it is easily accessible.

T F 3. Perforated pipe and porous dams are used to help settle solids in settling basins.

4. Name the three most commonly used methods to separate solids and liquids.

a.

b.

c.

5. Name two screening methods.

a.

b.

6. Name two disadvantages to using a dehydrator.

a.

b.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 8 - What methods of biological treatment are available?

Objective: Upon the conclusion of the lesson, students will be able to identify biological treatment systems, to list the advantages and disadvantages of each system, and to recognize the function and design of each system.

Study Questions:

1. What are the three methods of biological treatment available?
2. What are the advantages and disadvantages of anaerobic lagoons?
3. How is an anaerobic lagoon designed?
4. How is a lagoon constructed?
5. What are the advantages and disadvantages of aerobic treatment systems?
6. What methods of aeration are available?
7. How does composting work?
8. What is the deep pit system for poultry wastes?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 8 - What methods of biological treatment are available?

TEACHING PROCEDURE

A. Review

B. Motivation: What are the different types of lagoons? How are the wastes broken up in the lagoon? Do some methods of treatment smell more than others?

C. Assignment

D. Supervised Study: In class design a lagoon for a large cattle or hog operation.

E. Discussion

1. The biological processes are necessary to break up the organic matter in the manure. List the three methods of treatment on the board.

   What are the three methods of biological treatment available?

   1) Anaerobic processes require no oxygen breakdown of wastes.
   2) Aerobic processes require free oxygen and are odor free operations.
   3) Facultative microorganisms can break down wastes under conditions of oxygen or no oxygen.

2. List on the board the advantages and disadvantages of anaerobic breakdown. Brainstorm first; then review the text material.

   What are the advantages and disadvantages of anaerobic lagoons?

   1) Advantages
      a) Labor is saved in removal of liquid manure by usage of irrigation equipment.
      b) Long storage times free labor.
      c) High stabilization lowers manure odor when it is spread.
      d) No oxygen is required.
      e) Nitrogen reduction is an advantage if disposal area is small.
   2) Disadvantages
      a) Odors will increase if temperature and loading rates change.

b) Odors may generate during fall and spring turnover.
c) Anaerobic lagoons work best in high temperatures.
d) Fertilizer value is reduced by nitrogen loss.

3. How does the farmer calculate the size of a lagoon needed for anaerobic breakdown? What design factors must be considered?

How is an anaerobic lagoon designed?

1) Each design is different in various parts of the country.
2) Lagoons function best above 75°F.
3) Loading rate varies from .001 to .01 pounds of volatile solids per cubic feet per day.
4) A lagoon's minimum volume is based on climate and species of animals.
5) Lagoon size is determined by adding wastes which enter regularly to minimum design volume.
6) Lagoon size is determined by adding dilution volume of wastes normally entering--wash water, rain, or pumped well.
7) Add a safety margin of a 25-year, 24-hour rainfall when lagoon is nearly full.
8) Decide whether pumping cycle will be 1 or 2 times a year.
9) Two-stage lagoons require more total volume than one-stage lagoons.

4. Who in the class has helped to build a lagoon? Where did you put it? Did you have to line the walls? What accessories did you have to add?

How is a lagoon constructed?

1) Locate lagoon as far from home as possible.
2) Check odors and prevailing winds.
3) Locate near waste site.
4) Locate over impervious soils--contact SCS or Extension personnel.
5) Locate inlets beyond the bank toward the center of the lagoon.
6) Watch for the possibility of freezing pipes.
7) Shape should be approximately square or round.
8) Fill new lagoon 1/3 to 1/2 full of water after construction.
9) Start loading in the spring.
10) If pH (acidity or alkalinity of a solution) is below 6.7, odors will build. Add lime to raise the pH level.

5. What is the other type of lagoon system? What does it need to operate? Is the cost higher than an anaerobic lagoon? List the advantages and disadvantages of aerobic systems on the board. Discuss.

What are the advantages and disadvantages of aerobic treatment systems?

1) Advantages
    a) Aerobic system is relatively odor free.
    b) There is a fast rate of biological growth.
    c) Rapid adjustment to changes in loading and temperature is made.
    d) High temperature (70°F) is not required.
2) Disadvantages
    a) Oxygen is required.
    b) There is a high production of biological sludge.
    c) High space, maintenance, management, and energy requirements are essential for artificial oxygenation.
    d) Aerobic system needs a shallow depth with a large surface area.

6. The basic requirement for this type of waste breakdown is the need for oxygen for the aerobic bacteria. How can the oxygen be added?

What methods of aeration are available?

1) In naturally aerated systems, turbulence or algae produce oxygen.
2) Natural systems have a maximum depth of 5 feet with 3 feet to 4 feet preferred.
3) Depth under 3 feet causes problems with plant growth.
4) Depth over 5 feet causes problems with oxygen availability.
5) In mechanical systems, depths up to 20 feet are recommended.
6) Mechanical systems can add 3 pounds of oxygen per horsepower hour.
7) Oxidation ditches are continuous open channels with a mechanical rotor to churn waste materials.
    a) Advantages
        (1) It lowers odors in the building.
        (2) Total volume hauled is lower.
        (3) Rodents and insects do not infest.
        (4) Lower ventilation rates and lower odors are results of this system.
    b) Disadvantages
        (1) Cost of facilities can be expensive.
        (2) If there is a power failure, high labor is required.

        (3) Foaming problems are possible.
        (4) It is hard to install a system to an existing building.
    8) Plan for a 50-day capacity.
    9) Depth of rotor should be 4 inches to 6 inches or one-fourth of the liquid depth.
    10) Start aerator before adding manure.
    11) Foaming is controlled by vegetable or fuel oil of 1 pint per 2,500 gallons each day.
    12) If aerator has been off several days, use maximum ventilation before restarting. Gas production will be high.
    13) Look at the example on pages 64 and 65 of your reference for calculation of size of lagoon.

7. Compost is a mixture of decaying organic matter used as fertilizer. Composting is not a new method of handling animal wastes but is a method preferred if large amounts of bedding are included in the wastes. Put definition on the board.

    How does composting work?

    1) It is a biological breakdown of organic matter (volatile solids) into stable humus-like material.
    2) The objectives of composting
        a) It stabilizes odor producing OM.
        b) It kills pathogens and weed seeds.
        c) It conserves nutrients.
        d) It produces a stable product free of odors.
        e) It produces cheap products free from odors, insects, and rodents.
        f) It produces valuable/salable fertilizer and soil conditioner.
    3) Moisture content of 50% to 60% is best.
    4) Final result is .5% nitrogen, .4% phosphorus, and .2% potassium.

8. If poultry manure is to be handled, the deep pit method is suggested. The high nitrogen content of the manure makes it a good fertilizer.

    What is the deep pit system for poultry wastes?

    1) Eight-foot to 10-foot pits are under cages.
    2) Arrange to empty pit after each laying cycle.
    3) Keep water out of pit.
    4) Decomposition and drying reduces volume 80%.
    5) Stir manure for fast drying.

F. Summary

When planning the waste handling system, the type of biological breakdown must be carefully considered before building the livestock facilities. Whether the system is anaerobic, aerobic, or facultative will depend on the local environmental rules, the closeness of humans, and the systems utilized to move, store, and spread the wastes.

G. Evaluation

Answers to Exam

1. T
2. T
3. T
4. F
5. T
6. c
7. a
8. a. Anaerobic
   b. Aerobic
   c. Facultative microorganisms

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 8 - What methods of biological treatment are available?

EXAM

T F 1. Anaerobic means working without oxygen.

T F 2. An advantage to an anaerobic lagoon is the economy of labor.

T F 3. An advantage to the aerobic lagoon over the anaerobic lagoon is that it will continue to operate below 70°F.

T F 4. The depth of an oxidation ditch should be between 2 and 6 feet deep.

T F 5. Composting stabilizes organic matter through biological action.

_____ 6. Anaerobic lagoons operate most efficiently at a temperature of:

a. 40°F

b. 70°F

c. 90°F

_____ 7. If pH drops below _____, odors will increase from the lagoon.

a. 6.7

b. 7.5

c. 8.5

8. List the three methods of biological treatment.

a.

b.

c.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 9 - What methods are available for transporting waste?

Objective: Upon the conclusion of the lesson, students will be able to identify the waste transport systems available for moving manure.

Study Questions:

1. What is waste transport?
2. How is solid manure handled?
3. How is fluid manure up to 15% solids handled?
4. How are pumps selected for moving manure?
5. How can augers and piston pumps be used in manure transport?
6. Why agitate the manure before transporting it?
7. Where do tank wagons fit into the transport system?
8. How are the pipe sizes and accessories determined?
9. How can irrigation systems be used in waste transport?
10. How are slurries (4% to 15% solids) applied as fertilizers?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 9 - What methods are available for transporting waste?

TEACHING PROCEDURE

A. Review setting up lagoons and the volumes of wastes produced by livestock.

B. Motivation: How is waste transported on your farm? How much labor is involved? Are the costs justified by the amount of labor involved?

C. Assignment: List traditional methods of transporting waste as well as innovative methods the students might consider.

D. Supervised Study: Brainstorm transport methods, listing them on the board. Then list the advantages and disadvantages of each method.

E. Discussion

1. How are wastes moved on the farm? Which methods are the easiest or hardest to use? List the methods on the board and discuss each method.

   What is waste transport?

   1) Waste transport includes scraping, flushing, and runoff as well as hauling and piping.
   2) Range of solids content
      a) 20% to 25% - stiff
      b) 15% to 20% - semi-liquid
      c) 5% to 15% - liquid
      d) 0% to 4% - irrigation or flushing consistency

2. Wastes over 20% solids can easily be handled like a solid--meaning it can be removed by scraping and stored or hauled directly to the fields.

   How is solid manure handled?

   1) Most solid manure can be spread by conventional spreaders.
      a) Pull type spreaders haul 70 to 525 bushel capacities.
      b) Flail-type spreader capacity is figured on the ton basis or 1 ton equals approximately 27 bushels.

2) To calculate capacity:
   a) $$\text{Number of trips} = \frac{\text{cubic feet manure to be spread}}{\text{spreader capacity in bushels} \times 1.25 \text{ cubic feet per bushel}}$$

   b) $$\text{Number of trips} = \frac{\text{tons to be spread}}{\text{tons per load}}$$

3. Manure consisting of as much as 15% solids can be handled as a fluid. By using flour and water, demonstrate to show the change in consistency of materials. As solid percent increases, add more and more flour to the water.

How is fluid manure up to 15% solids handled?

1) The manure is semi-liquid.
2) Pumps can be used if fiber is low.
3) Use slurry or trash pumps if trash is present.
4) Limit oversize solids.
   a) Settle out solids.
   b) Screen pump.
5) Pump capacity is influenced by:
   a) Amount of wastes
   b) Time, labor, and power available
   c) Route of liquids
   d) Cost of labor and equipment
6) Use safety devices on pumps.
7) Increase pump horsepower 10% for increased friction and specific gravity of wastes.
8) Slurries 4% to 15% require high head pressure to flow through the pipelines. It is suggested to transport in channels.
9) Pumps for 4% to 15% solids need to be heavy duty.

4. Selection of pumps is very important and must be done carefully to prevent high maintenance costs. Practice calculations of horsepower.

How are pumps selected for moving manure?

1) For runoff or lagoon effluent, a single-stage standard centrifugal pump should be selected.
2) Use pumps made of all plastic and rubber to prevent crystal build-up on metals.
3) If solid content is near 15%, use an open impeller chopper pump.
4) $$\text{Horsepower} = \frac{\text{discharge in gpm} \times \text{pressure in feet of liquid}}{3{,}960 \times \text{pump efficiency in percent}}$$

5) $$\text{Or horsepower} = \frac{\text{discharge in cfs} \times \text{pressure in feet}}{8.8 \times \text{pump efficiency in percent}}$$

NOTE: In steps 4 and 5, percent must be changed to a decimal.

6) Submerged open impeller centrifugal pump:
   a) Delivers up to 3,000 gpm
   b) Agitates storage
   c) Fills tank wagons
   d) Fits various choppers

5. In building pits with no bottom gravity drain, a removal system is needed to move the manure to storage or to the field. What methods will move manure upward efficiently?

How can augers and piston pumps be used in manure transport?

1) Augers
   a) Augers are electric or PTO driven.
   b) One to 5 hp lifts 40 to 180 gpm with a 4-inch to 6-inch auger.
   c) Clean after use to prevent corrosion.
2) Vacuum tank wagon
   a) Air pump forces air out and pulls manure into tank wagon.
   b) Tank wagon sucks manure slurry through a large diameter hose.
   c) Vacuum tank wagon removes wastes by reversing the pressure.
3) Piston pumps
   a) Piston pumps are used to move waste through 8-inch to 12-inch pipes.
   b) Piston pumps are used for bottom loading piles to keep odors low.
   c) Solid piston is 10 inches to 15 inches in diameter.
   d) Hydraulic drive operates pump piston.
   e) Check valve prevents backflow.
   f) Hollow piston pump is used for long bedding waste.
   g) Pumping distances vary up to 300 feet.

6. How is manure agitated. What methods are available to agitate it?

Why agitate the manure before transporting it?

1) Solids need to be in suspension before pumping.
2) Characteristics of agitation vary with feeding ration, amount of drying, and length of storage.
3) Little agitation is needed for narrow gutters drained by gravity.
4) Use tanks, round or square, with a dimension under 40 feet to agitate manure.

5) Agitators include paddle wheels, augers, and vacuum tanks.
6) Provide air movement during agitation.

7. The use of tank wagons is a common method of waste movement for smaller operations. Where are they used in the community?

Where do tank wagons fit into the transport system?

1) Tanks hold about 5,000 gallons.
2) Vacuum tanks are the most reliable method of waste movement because there is no flow of materials through moving parts.
3) Subsurface injection of slurries reduces offensive odors and nutrient loss.

8. Pipe is easily adapted to most waste disposal systems because they can be easily hidden and are airtight for full flow from the manure source to storage. What problems may the farmer encounter?

How are the pipe sizes and accessories determined?

1) Small pipe can be used for flushing systems and diluting water.
2) Large pipe is used for irrigation and water control.
3) Small pipe can be made of steel, copper, aluminum, or plastic.
4) Large pipe for irrigation is aluminum or plastic; steel, cast iron, plastic or asbestos-cement pipes are used for culverts and drains.
5) Check the friction loss. (See page 72 of your reference.)
6) Pump size should match pipe capacities.
7) Uses of pipeline
    a) Pipeline is economical in moving large amounts of waste.
    b) Effluent from ponds can be easily pumped.
    c) Pump lot runoff to crops or grass.
    d) A small pump and pipe can transfer liquids to a remote spot.
8) Consider fluid velocity. Velocity wanted is 3 to 6 fps.
    a) If fluid velocity is 1 1/2 fps or lower, solids settle in low spots.
    b) If fluid velocity is over 6 fps, water hammering may result.
9) Sprinklers vary in sizes. Nozzles are 1 inch or larger or gpm flow is 1,000 or more.
10) Discharge is controlled by nozzle size, number of nozzles, and operating pressure.

11) Sprinklers have 1 to 3 nozzles.
12) Minimum operating psi is 20 to 90 psi.

9. Planning a good irrigation system can provide the farmer with a low labor method of disposing waste. What type of system is used in your area?

How can irrigation systems be used in waste transport?

1) Most irrigation systems can handle wastes up to 4% solids.
2) Flood irrigation and big guns can handle more solids.
3) The system should adapt to topography, soil, and crops.
4) Potential problems
    a) Odor
    b) Adverse affect on plant growth
    c) Low soil permeability
5) For surface irrigation, slope should be 2% or less.
    a) Border irrigation floods field with water 3 inches to 5 inches deep.
    b) Furrow irrigation spreads water in furrows.
    c) In corrugation irrigation, small V-notches are made.
    d) Wild flooding has an uneven water and fertilizer distribution.
    e) Surface irrigation has a low cost but requires a high degree of skill.
6) Sprinkler systems used on uneven land are satisfactory.
    a) Handmove system is low cost but requires high labor.
    b) Towline system is a low labor, low investment system but can be a problem on an irregular field.
    c) Big gun system is flexible but demands a high initial investment and high power requirements.
7) Water irrigation systems apply up to 20 inches of water each year in at least three applications.
8) Consider soil type and moisture before irrigating. (See table on page 79 of your text.)

10. Large slurries of 4% to 15% solids can be applied by using a big gun sprinkler. Care must be taken when spreading wastes.

How are slurries (4% to 15% solids) applied as fertilizers?

1) Big gun system is similar to the lower solid systems. Select a pipeline specifically for larger volume.

2) PVC plastic pipe with adequate psi rating is suitable.
3) Solids may coat leaves and require rinsing.
4) Watch for leakage when moving the system as leakage in high concentration can kill crops.
5) If possible, pump clean water 10 to 15 minutes to clear pipe clogs and to rinse the system.

F. Summary

The transportation of wastes is primarily based on two factors: waste liquidity and available labor. If a low labor system is needed, the manure must be kept liquid so it can move easily through the pipes. If labor is available, the amount of solids can be higher and moved in larger loads at less frequent intervals than waste materials moved through the liquid system.

G. Evaluation

Answers to Exam

1. T
2. T
3. T
4. T
5. F
6. T
7. T
8. T
9. a. Reduced odor
   b. Reduced nutritional loss

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 9 - What methods are available for transporting waste?

EXAM

T F 1. For irrigation, solids should range from 0% to 4%.

T F 2. Up to 15% solids in manure can still be handled as fluid waste.

T F 3. When planning to pump manure, friction losses require a pump with a horsepower increase of 10% over the water capacity.

T F 4. A vacuum tank uses air pressure to draw manure into the tank.

T F 5. Surface irrigation works best with a slope of 5%.

T F 6. An irrigation system can apply 20 inches of water a year.

T F 7. Motor parts should be made of plastic and rubber to avoid corrosion.

T F 8. Agitation releases noxious gases from the manure and should be ventilated from the buildings.

9. Two advantages to subsurface injection are:

a.

b.

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 10 - How will end products of livestock wastes be effectively and profitably utilized on the farm?

Objective: Upon the conclusion of the lesson, students will be able to effectively and profitably utilize the end products of livestock wastes.

Study Questions:

1. What practical uses of animal wastes are available?
2. What are the effects of land application?
3. How does it affect surface and groundwater quality?
4. What are the nutrient losses during collection and storage?
5. What are the methods of application available?
6. What soil characteristics affect application?
7. What is the nutrient value per animal unit and nutrient value for crop production?
8. How much waste can be applied?
9. What other management considerations are there?

Reference:

1. Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 10 - How will end products of livestock wastes be effectively and profitably utilized on the farm?

TEACHING PROCEDURE

A. Review basic sources, transport, and storage of waste.

B. Motivation: What disposal systems have you used? How is manure stored? How is it spread on the fields?

C. Assignment: Set up a disposal system time schedule for a small farm with a list of removal and spreading equipment needed.

D. Supervised Study

E. Discussion

1. Regardless of the storage, treatment, and handling methods used for animal wastes, some end products remain. These end products are valuable resources to be effectively and profitably utilized.

   What practical uses of animal wastes are available?

   1) Land application as fertilizer and soil conditioner
   2) Supplement water needs for crop production
   3) Reuse of liquids to flush and transport manure
   4) Reuse processed solids as bedding
   5) Processed as fertilizer for off-farm, soil additive or mulch
   6) Salvage energy
   7) Reuse as food

2. The direct disposal of manure on farm land is desirable from a nutritional standpoint. What other positive and negative ways can manure affect the land?

   What are the effects of land application?

   1) It improves tilth, water-holding capacity, erosion control, aeration, and growth of beneficial organisms.
   2) Irrigation water is provided when wastes include runoff.
   3) Waste disposal is economically valuable in N (nitrogen), P (phosphorus), and K (potassium) contents.

4) Excess application can harm crops, water quality, and waste nutrients.
5) Excess build-up of phosphorus can interfere with trace element uptake for plant nutrition.
6) Organic material drops oxygen.
7) With organic build-up, C/N (carbon-nitrogen) ratio can limit N uptake of plants.
8) Heavy application can increase salt build-up in the soil.
9) Sodium and potassium in the soil can reduce water movement.

3. Land-applied wastes are a potential pollution hazard to surface and groundwater, depending on the disposal practices and the characteristics of the disposal area.

   How does it affect surface and groundwater quality?

   1) Several disease organisms that infect humans and animals are in water-borne animal wastes.
   2) Runoff contains pollutants causing nitrate pollution.
   3) Nitrate high water can cause infant cyanosis or diarrhea.
   4) Check soils for leaching rates. A SCS or Extension specialist can help.
   5) The biggest problem of large nutrient losses is when manure is applied to frozen ground.

4. Nutrient losses can occur between the animal and the application to the soil. How can this happen? What factors can reduce the nutrient?

   What are the nutrient losses during collection and storage?

   1) The type of housing and handling system can affect nutrient composition.
   2) Bedding and water dilute manure and reduce nutrient value per pound or gallon.
   3) Ammonia is a result of a loss of nitrogen from the air.
   4) Less ammonia is lost from deep waste disposal systems than other waste disposal systems.
   5) Five percent to 15% of K or P is the maximum lost in handling except for open lots or lagoons.
   6) Fifty percent P and 40% K can be lost in open lots.
   7) Eighty percent P and N is lost in lagoons.

5. Application methods were discussed in the previous lesson. Ask the class to list application methods and nutrient loss reduction methods. Summary follows.

What are the methods of application available?

1) Broadcast with incorporation reduces N loss.
2) Broadcast without incorporation increases N loss.
3) Knifing minimizes odors and nutrient loss.
4) Irrigation results in 30% N loss.

6. Soil type will affect the waste application. What soil types are in your area? Run soil absorption tests in jars and discuss the results.

What soil characteristics affect application?

1) Light textured soils decompose organic matter faster.
2) Heavier textured soils hold more nutrients.
3) Properties affecting application include infiltration rate, holding capacity, texture, and exchange capacity.
4) Apply animal wastes throughout the growing season on coarse textured soils.

7. To apply fertilizer accurately, the soil must be tested before fertilizer rates are determined. What do you look for in a natural fertilizer? What does it add to the soil?

What is the nutrient value per animal unit and nutrient value for crop production?

1) For values per animal
    a) Number of animals X weight of animals = liveweight.
    b) Liveweight divided by 1,000 per unit = 1,000 pound units.
    c) From tables on pages 82 and 83 of your text, calculate pounds of N, P_2O_5, and K_2O.
2) For crop production use the following conversion factors:
    a) Multiple P_2O_5 by .44 to get P.
    b) Multiple K_2O by .83 to get K.
    c) One bushel manure spreader capacity = 35 to 40 pounds.
    d) One thousand gallons = 4 tons (approximately).
    e) Twenty-seven thousand, one hundred fifty-two gallons = 1 acre-inch.
3) Organic nitrogen is slow release. Ammoniated N is fast release.
4) Seventy percent to 80% P and 70% to 90% K in animal wastes are available during the year.
5) To calculate amount of waste to apply to the crops, you must first determine a) and b).

a) Nutrient needs of crop
b) Fertilizer value of manure
c) Amount of manure needed equals nutrient needs (step a) divided by fertilizer value in tons or gallons per acre (step b).
d) Pounds per 1,000 gallons (step c) X application rate = nutrients of waste.
e) Crop needs (step a) minus nutrients of waste (step d) = fertilizer needs.

8. There are other management considerations that apply to the spreading of waste.

What other management considerations are there?

1) Check state and local regulations on spreading.
2) Surface-apply animal wastes at least 100 feet from water.
3) When ground is frozen, apply to level ground.
4) To control odors, spread wastes in the morning when air is rising; avoid windy days.
5) Agitate to get solids.

F. Summary

To utilize the animal wastes produced through the livestock operation, a plan of programmed removal and application must be developed for the farm. A well developed plan considers surface drainage, soil type, groundwater pollution, nutrient loss, and application rates before wastes are spread. The methods and rates will be developed upon individual need and available finances and labor.

G. Evaluation

Answers to Exam

1. T
2. T
3. T
4. F
5. T
6. Any five of the following:
   a. Land application as fertilizer and soil conditioner
   b. Supplement water needs for crop production
   c. Reuse of liquids to flush and transport manure
   d. Reuse processed solids as bedding
   e. Processed as fertilizer for off-farm, soil additive or mulch
   f. Salvage energy
   g. Reuse as food

UNIT - LIVESTOCK WASTE MANAGEMENT

Lesson 10 - How will end products of livestock wastes be effectively and profitably utilized on the farm?

EXAM

T F 1. An increased amount of organic matter in wastes can reduce the oxygen content of soils.

T F 2. A high loss of phosphorus and potassium will occur in open lot runoff of manure.

T F 3. A high loss of phosphorus and nitrogen will occur when manure is stored in a lagoon.

T F 4. Leaching is not a problem when applying solid manure to fields.

T F 5. Knifing in manure will save nutrients and minimize odors.

6. List five uses of livestock waste.

a.

b.

c.

d.

e.

UNIT - LIVESTOCK WASTE MANAGEMENT

ASSIGNMENT SHEET

Objective: By the conclusion of the assignment, the student will be able to calculate the waste storage capacity needed on a farm with 200 beef feeeders and 300 swine feeders.

Formulas:

1. Total storage volume required, cu. ft. = Daily storage required per animal unit, cu. ft. x Number of animal units x Days of storage required
2. Manure, cu. ft. = Daily raw manure produced per animal unit
3. Bedding, cu. ft. = 1/2 x Bedding used in pounds ÷ Density of bedding material in lb./cu. ft.
4. Daily storage required per animal unit, cu. ft. = Manure voided, cu. ft. + Bedding, cu. ft. - Manure voided but not stored, cu. ft.

Tables Required:

Livestock Waste Facilities Handbook, by Midwest Plan Service, available through Extension Agricultural Engineer, Extension Division, University of Missouri-Columbia, Columbia, MO 65211 $2.50

Table 1: Manure Production and Characteristics, pg. 5
Table 2: Daily Manure Production, pg. 4

Procedure:

PART 1: FECES AND URINE PRODUCTION

Step 1: Calculate the feces and urine produced per animal. From Table 1, find the raw manure produced by:

1. Beef feeders _____wt./day _____% feces _____% urine
2. Swine feeders _____wt./day _____% feces _____% urine

Step 2: From the same table, find the feces content of each.

Step 3: To calculate the cubic feet of feces and urine per day, complete the following:

Beef 500 pounds each.

In Table 2, find the total manure production in cubic feet per day for a 500 pound beef __________.

Step 4: Complete the following formulas:

_____% feces in raw manure x

_____ cubic feet of manure production per day

cubic feet feces/day per beef

Step 5: _____% urine in raw manure x

_____ cubic feet of manure production per day

cubic feet urine/day per beef

Step 6: Repeat the process with the swine, finishing (150 lbs.).

Step 7: To find the cubic feet of feces/day and urine/day, multiply the cubic feet per animal times the number of animals. Add together the beef and swine amounts.

Example: _____ cubic feet feces/day per beef or swine

x 200 beef feeders or 300 swine feeders

cubic feet of feces/day for beef or swine

Step 8: The following need to be found:

1. _____ cubic feet feces/day/beef
2. _____ cubic feet urine/day/beef
3. _____ cubic feet feces/day/swine
4. _____ cubic feet urine/day/swine
5. _____ cubic feet of feces total
6. _____ cubic feet of urine total

PART 2: BEDDING MATERIAL

At this point the bedding material that will enter the storage area needs to be calculated. With this assignment no bedding will be used.

PART 3: TOTAL STORAGE VOLUME

Step 1: To calculate the total storage volume required, add the solids, urine, and bedding (if any) together and multiply times the number of days of storage needed.

Step 2: ______ cubic feet of feces total x

180 days (storage time)

storage capacity for feces in cubic feet

Step 3: ______ cubic feet of urine total x

180 days (storage time)

storage capacity for urine in cubic feet

Step 4: ______ storage capacity in cubic feet/feces +

______ storage capacity in cubic feet/urine

storage capacity needed for farm

ANSWER SHEET

LIVESTOCK WASTE MANAGEMENT ASSIGNMENT SHEET

PART 1: FECES AND URINE PRODUCTION

Step 1: 1. Beef 60 wt./day 71% feces 29% urine

2. Swine 65 wt./day 55% feces 45% urine

Step 2: 500 pound beef .5 cu. ft./day
71% feces x .5 = .355 cu. ft./day/beef
29% urine x .5 = .145 cu. ft./day/beef

finishing hogs .16 cu. ft./day
55% feces x .16 = .088 cu. ft./day/hog
45% urine x .16 = .072 cu. ft./day/hog

Step 3: .50

Step 4: Total beef
.355 x 200 = 71 cu. ft./feces/day all beef

Step 5: .145 x 200 = 29 cu. ft./urine/day all beef

Step 6: Total swine
.088 x 300 = 26.4 cu. ft./feces/day all swine
.072 x 300 = 21.6 cu. ft./urine/day all swine

Step 7: Total feces: 71 + 26.4 = 97.4 cu. ft. feces
Total urine: 29 + 21.6 = 50.6 cu. ft. urine

PART 3: TOTAL STORAGE VOLUME

Step 2: 97.4 cu. ft./feces x 180 = 17,532 cu. ft.

Step 3: 50.6 cu. ft./urine x 180 = 9,108 cu. ft.

Step 4: Total storage capacity
in cu. ft. 26,640

UNIT - BUILDING FENCES

Lesson 1 - How do I lay out and clear fence lines?

Objective: Upon the conclusion of the lesson, students will be able to lay out and clear fence lines.

Study Questions:

1. What tools are needed to lay out a fence line?
2. How is a fence line laid out in heavy underbrush?
3. How are fences laid out on open level land?
4. How are fences laid out on rolling land?
5. How are fences laid out on contoured land?
6. What tools are needed to clear a fence line?
7. How is a fence line cleared with a bulldozer?
8. How is a fence line cleared with a tractor and harrow?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 1 - How do I lay out and clear fence lines?

TEACHING PROCEDURE

A. Review

B. Motivation: How many different types of fences can you name? Where have you seen each used? How many of you have seen a fence line laid out and cleared?

C. Assignment

D. Supervised Study: Set up a situation of controlling the grazing of a herd of cattle and plan the location of the fence lines.

E. Discussion

1. Find as many tools as you can that are used in layout and have them in the classroom during your presentation. Use drawings on the board if necessary. Use correct procedures in class to promote safe handling of tools.

   What tools are needed to lay out a fence line?

   1) Axe
   2) Bank blade
   3) 100-foot tape
   4) 5-foot stakes
   5) Flags
   6) Twelve- to 15-foot flag pole
   7) Level
   8) String

2. Refer to the drawings on page 6 of the reference to show the problems of heavy underbrush.

   How is a fence line laid out in heavy underbrush?

   1) Use flag pole at end of fence line in heaviest growth.
   2) Place 5-foot stake at other end.
   3) Sight with short stake to tall pole to align middle poles.
   4) Clear between short and middle stake.
   5) Repeat process from middle to end as in steps 3 and 4.
   6) Refer to drawings on pages 6 and 7 of the reference.

3. The method of sighting similar to the heavy underbrush method is again used.

   How are fences laid out on open level land?

   1) Set stake at each end.
   2) Move 100 feet towards end stake and align.
   3) Repeat the process.

4. This procedure is more difficult and must be done carefully to insure a straight fence.

   How are fences laid out on rolling land?

   1) Set stakes at each end of proposed fence.
   2) Place 2 stakes 10 feet apart on top of hill so both are visible.
   3) Align stakes from one end.
   4) Check from other end.
   5) May need to move stakes several times.

5. There will be times when a fence must follow the contour of the land whether manmade (terrace or contour strip) or natural.

   How are fences laid out on contoured land?

   1) Stake out a smooth curve, setting stakes 16 feet apart.
   2) If a lot of curve is at one point, select 3 stakes at point of greatest curvature.
   3) Stretch string between outside stakes.
   4) Measure distance from string to middle stake.
   5) Decrease spacing according to chart on page 10 of the reference.
   6) Set stakes for proper placing.
   7) Repeat steps 3 to 6 where needed.
   8) Check by sight for curvature.

6. Have needed tools handy for tool identification. Demonstrate proper use of tools.

   What tools are needed to clear a fence line?

   1) Leather gloves
   2) Axe
   3) Swing blade
   4) Mattock
   5) Shovel
   6) Bank blade
   7) Bulldozer or tractor
   8) Wrecking bar
   9) Hammer

7. The easiest method to use to clear a fence line is a bulldozer if a fast job is required. Use professional help to reduce unwanted damage.

How is a fence line cleared with a bulldozer?

1) Detach good fence from posts and save the good posts.
2) Drive bulldozer ahead until blade is loaded.
3) Empty load.
4) Float blade over cleared area.

8. Using farm tractors is another way--but slower. Extra equipment is needed to pull posts and safety is a problem.

How is a fence line cleared with a tractor and harrow?

1) Remove old posts with tractor.
2) Remove large trees, allowing 20 feet minimum for fall.
3) Pile material for rotting.
4) Use harrow to level.

F. Summary

Proper sighting is important in aligning the posts. It might be beneficial to sight using a builder's level rather than the eye.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. T
6. T
7. T
8. F

UNIT - BUILDING FENCES

Lesson 1 - How do I lay out and clear fence lines?

EXAM

T F 1. The first sighting when laying out a fence line is from the start to the middle post.

T F 2. On level land, sight each post every 100 feet.

T F 3. On rolling land, sight with a point on the horizon.

T F 4. Contour fencing follows the natural curvature of the land.

T F 5. A bulldozer can be used to clear fence rows.

T F 6. Posts should be pulled upward, not sideward.

T F 7. Floating the blade of a bulldozer will improve the fence line.

T F 8. A 20-foot wide path is a minimum for installing fence.

UNIT - BUILDING FENCES

Lesson 2 - How do I install braces and posts?

Objective: Upon the conclusion of the lesson, students will be able to set and brace wood and steel posts.

Study Questions:

1. What are the tools and materials needed to install braces and wood posts?
2. Where do you locate wood-and-steel and anchor-and-brace assemblies?
3. How do you install the assemblies?
4. How is the brace wire installed?
5. How are the wood line posts installed?
6. What tools are needed for braces and steel posts?
7. How do you install steel post-and-brace assemblies?
8. How are steel line posts installed?

References:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Transparencies
    a. TM-1: Anchor-and-Brace Assembly

UNIT - BUILDING FENCES

Lesson 2 - How do I install braces and posts?

TEACHING PROCEDURE

A. Review

B. Motivation: How many of you have helped to build a fence? Have you installed braces? Have you set posts?

C. Assignment

D. Supervised Study: Construct a brace-and-post assembly near the school or set the posts in concrete to practice bracings and stretching.

E. Discussion

1. Selection of tools is very important and their maintenance must also be stressed. Have as many of the tools available in the classroom as possible. Demonstrations should also be conducted.

   What are the tools and materials needed to install braces and wood posts?

   1) Diggers
   2) Tamping bar
   3) Axe
   4) Spade
   5) Claw hammer
   6) Handsaw
   7) Wire splicer
   8) Brace and bit
   9) Steel dowels
   10) Staples
   11) Brace wire
   12) Level
   13) Six-inch rule
   14) Marking crayon
   15) Twine

2. Locating the bracing assemblies is important for added strength. Discuss the common failures of fences: sagging, giving under pressure, etc.

   Where do you locate wood-and-steel and anchor-and-brace assemblies?

1) For straight fences on flat land that are 10 rods or less in length, use single span.
2) For a fence ten to 40 rods, use Z-span (2 span).
3) For a fence over 40 rods, use braced-line-post assembly.
4) For straight fences, on rolling land, use braced-line-post assemblies at foot and top of hill.
5) Curved fence needs braced-line-post assembly, each 20 rods or less in straight section.

3. Practice marking the depths of posts and digging holes to the proper depth.

How do you install the assemblies?

1) Mark ground line on anchor-brace posts.
2) Dig hole for anchor post.
3) Place pole in hole and tamp while checking level.
4) Measure from anchor post to first brace post.
5) Dig hole for second post and place post in hole.
6) Mark dowel hole 8 to 12 inches from top of post.
7) Bore hole for dowel 2 inches deep in anchor post.
8) Bore hole 2 inches deep in brace.
9) Insert dowel in anchor post.
10) Install brace member.
11) Repeat on brace post.
12) Tamp soil around brace post.

4. Be sure the 2 posts are level and the brace is secured and level before continuing. Use TM-1: Anchor-and-Brace Assembly

How is the brace wire installed?

1) Drive staple 4 inches above brace on opposite side of brace post.
2) Drive staple 4 inches from ground on outside of anchor post.
3) Unwrap 2 loops of brace wire to fit between the staples.
4) Thread wire through staples.
5) Wrap wire around anchor post and return toward brace post.
6) Use enough wire for 2 loops plus a 6- to 12-inch overlap of the ends.
7) Splice.
8) Twist wires from the center of the loops with a pipe or stick until rigid.
9) If over 40 rods, use 4 brace wires on a braced-line-post assembly.

5. After setting the brace posts, the intermediate posts need to be set and should be aligned using a stretch line or a builder's level.

How are the wood line posts installed?

1) Stretch cord between anchor-post assemblies.
2) Measure line post spacings with gage pole.
3) Mark ground line on posts.
4) Dig holes to proper depth.
5) Set and align posts.
6) Posts in low places may need additional weight.
7) Wet places need special posts.
8) If a gully is 16 feet wide or less, span with wire.
9) If a gully is over 16 feet wide, use anchor-and-brace on each side.
10) Filler fences may be needed in low spots in a gully.

6. The use of steel posts is on the rise due to their longevity and ease of installation. Have students drive posts and have tools handy during demonstrations.

What tools are needed for braces and steel posts?

1) Steel post driver
2) Adjustable end wrench, open end wrench set
3) Gage stick
4) Carpenter's level
5) Cement
6) Sand
7) Crushed stone
8) Water
9) Three and one-half cubic feet of concrete for an end post; 4 1/2 cubic feet of concrete for corner post (1 part cement, 2 parts sand, and 4 parts crushed stone is needed to mix cement).

7. The anchoring of steel post-and-brace units is extremely important. Have the students mark and dig the holes to brace the metal posts.

How do you install steel post-and-brace assemblies?

1) Dig anchor post hole and mark ground line on post.
2) Bolt brace(s) to anchor post.
3) Dig hole where brace end contacts ground (need 8 inches of concrete below frost line).
4) Mix and place concrete around anchor post and brace(s). Let cure for 1 week.

8. The steel posts are aligned like the wood ones and are often used with wood brace-and-anchor assemblies.

How are the steel line posts installed?

1) Align the posts with line and gage.
2) Mark ground line.
3) Be sure wire holders are on the side you want to attach to wire.
4) Drive posts and check alignment.

F. Summary

A combination of the wood and metal can be used with success to build a fence. Plan ahead and be sure the posts are all aligned.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. F
6. T
7. F
8. T
9. T
10. F

UNIT - BUILDING FENCES

Lesson 2 - How do I install braces and posts?

EXAM

T F 1. One-span ends are used for fences over 40 rods long.

T F 2. A braced-line-post assembly is used on fences over 40 rods long.

T F 3. The dowel is used to align the posts.

T F 4. Two loops are suggested for the brace wire assembly.

T F 5. A gage pole is used to measure the depth of dug holes.

T F 6. Gaps of 16 feet can be easily crossed with simple line posts.

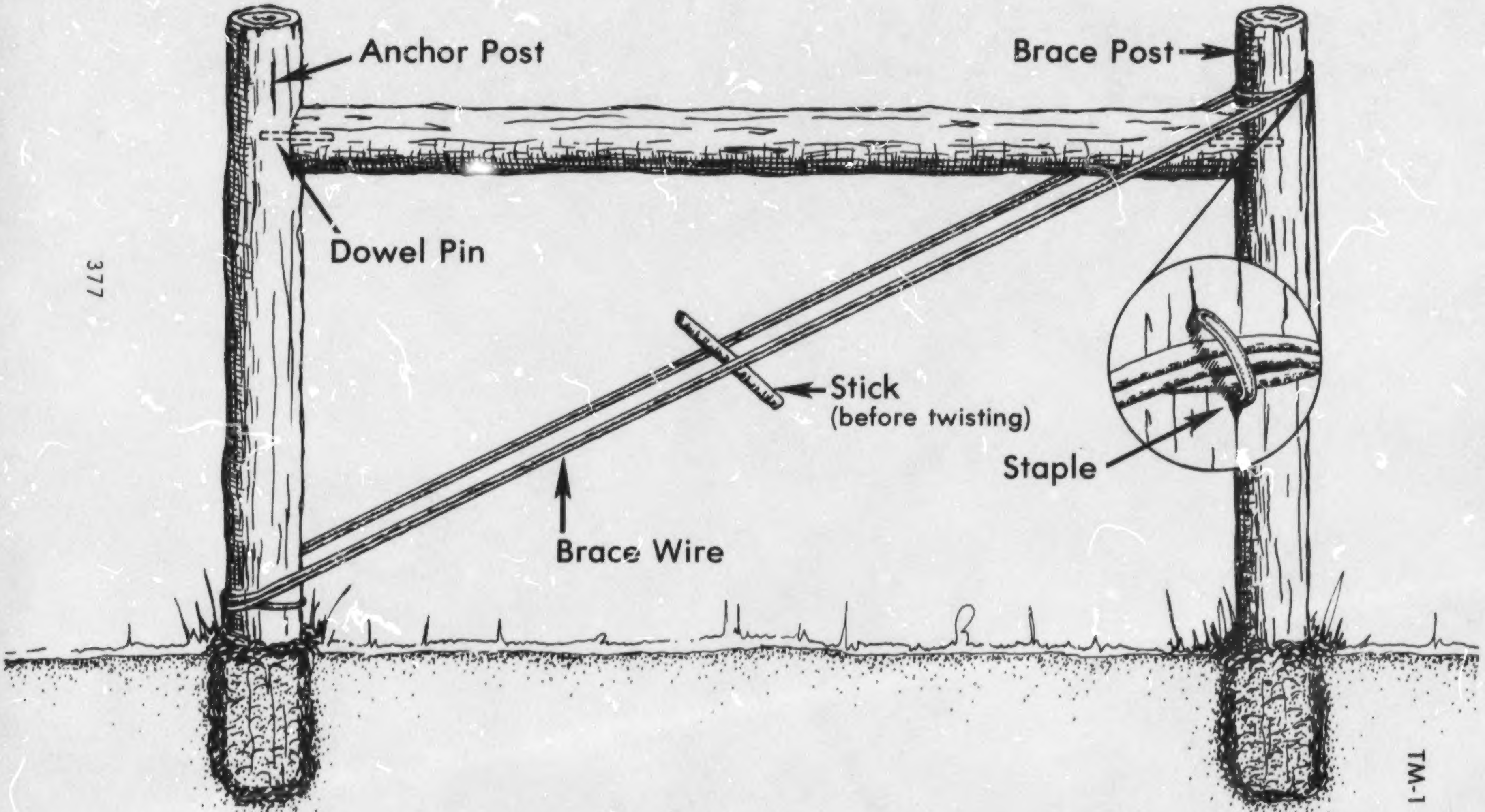
T F 7. Suggested concrete mix for steel brace posts is 2 parts cement, 2 parts sand and 2 parts crushed stone.

T F 8. The concrete should be 8 inches below the frost line for the braces.

T F 9. Wood and steel posts can be mixed in a fence line.

T F 10. Low, wet areas need not be fenced because the animals won't cross them.

Anchor and Brace Assembly



Anchor Post
Brace Post
Dowel Pin
Stick
(before twisting)
Staple
Brace Wire

TM-1

UNIT - BUILDING FENCES

Lesson 3 - How do I build barbed wire and woven wire fences?

Objective: Upon the conclusion of the lesson, students will be able to build barbed wire and woven wire fences.

Study Questions:

1. What tools and materials are needed to install barbed wire fences?
2. How is barbed wire laid out on the fence line?
3. How is barbed wire stretched?
4. How is barbed wire attached?
5. What tools are needed for woven wire?
6. How is woven wire laid out?
7. How is woven wire stretched?
8. How is woven wire attached?
9. How is a fence grounded for lightning protection?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 3 - How do I build barbed wire and woven wire fences?

TEACHING PROCEDURE

A. Review lessons 1 and 2.

B. Motivation: Who has stretched barbed wire before? Have you been cut by the wire? How can you protect yourself?

C. Assignment

D. Supervised Study: Stretch wire between two posts set in concrete, using the different methods available.

E. Discussion

1. Have the tools available for inspection at the beginning of class. Demonstrate each of the tools and cover the maintenance of each tool.

    What tools and materials are needed to install barbed wire fences?

    1) Fence stretchers
    2) Staples
    3) Wire clamps
    4) Eighteen- to 24-inch rod
    5) Claw hammer
    6) Fencing pliers
    7) Wire splicer
    8) Leather gloves

2. Select the proper wire for the job and have all tools ready for use.

    How is barbed wire laid out on the fence line?

    1) Determine spacing and number of spans.
    2) Attach wire to end post.
    3) Extend wires around post and wrap.
    4) Unroll wire to next anchor post (use gloves).

3. There are several methods of stretching wire, so poll the class as to the most common method used in your area.

    How is barbed wire stretched?

1) Erect dummy post for attaching stretcher.
2) Attach stretcher to dummy post.
3) Attach end of wire to stretcher SECURELY.
4) Stretch barbed wire until tight.
5) Check wire to make sure it is free.
6) Do not stretch too tightly.

4. The wire must be securely attached to the post. Have students practice driving staples in thin wood without causing grain cracks.

   How is barbed wire attached?

   1) Set staple cross-wise of grain.
   2) Drive staple into post.
   3) Attach stay wires if it is a suspension fence.
   4) With steel posts, hook post clamp over wire and snap around post.
   5) Bend other side of wire or bend logs over wire.
   6) On concrete posts, use a U-shaped wire behind post and wrap around barbed wire on either side of the post.

5. Have the tools out for inspection and demonstrate each tool.

   What tools are needed for woven wire?

   1) Stretcher
   2) Jack or block and tackle
   3) Rod
   4) Wire clamps or staples
   5) Compression fittings
   6) Splicing tool
   7) Hammer
   8) Pliers or fencing tool
   9) Crimper

6. Show how to lay out the woven wire roll with close-mesh on the bottom.

   How is woven wire laid out?

   1) Look at roll and determine which end of fence row to start.
   2) Start unrolling 2 feet past anchor post.
   3) Remove one stay from top to bottom.
   4) Stand fence against anchor post and set to desired height.
   5) Staple into position.
   6) Extend end of each line around post, wrap around post, and secure to fencing material.
   7) Complete unrolling to next anchor post assembly.
   8) If you must splice,

  a) Cut ends to a 4-inch overlap.
  b) Bend top line wire of one fence over top of roll of fencing and wrap.
  c) Wrap other top line in opposite direction.

9) If you must crimp,
  a) Overlap two inches.
  b) Place compression fitting over both wires.
  c) Crimp fitting.

7. Do not use a tractor to stretch the wire; it has been proven that the wire can snap and kill. Use the approved stretchers.

How is woven wire stretched?

1) Erect dummy posts.
2) Stand fence against line posts.
3) Attach chains of stretchers to dummy.
4) Attach clamp bar to fence.
5) Attach ratchets to clamp bar.
6) Tighten slowly, alternating between ratchets.
7) Stretch until 1/3 of tension curves are removed.

8. Attaching the wire requires skill in driving staples or using hooks. First practice the skills on scrap lumber.

How is woven wire attached?

1) Attach wire to post with staple cross-wise to grain at a slight down angle. With steel posts, clamp, snap, and wrap. Form U with wire and wrap concrete posts.
2) Remove stay wires to allow for wrapping around post.
3) Cut middle wire and wrap around post to wire.
4) Repeat with every other wire--top to bottom
5) Leave top wire for last.
6) Attach top wire to other line posts.
7) Attach bottom wire.
8) Attach others.
9) Add barbed wire if needed.

9. Lightning protection is essential for protection of livestock from electrocution. Farm fences can carry a killing charge two miles.

How is a fence grounded for lightning protection?

1) Drive the grounding rod into the ground 5 feet so 6 inches sticks above the fence post.
2) Strap the pipe to a fence post so it contacts the wire.
3) An electric fence is grounded by:
    - a) Driving a rod 8 feet into the ground every 300 feet
    - b) Installing a lightning arrestor to the fence post
    - c) Attaching leads to wires from the lightning arrestor
    - d) Attaching No. 6 copper wire to pipe
    - e) Checking wire (No. 6 copper) to insure it is not grounding the fence

F. Summary

The most common types of fencing used for livestock are barbed wire and woven wire. Care must be taken not to overstretch the wire or make long runs without using enough posts to support the weight of the wire.

G. Evaluation

Answers to Exam

1. T
2. F
3. T
4. F
5. T
6. T
7. T
8. F

UNIT - BUILDING FENCES

Lesson 3 - How do I build barbed wire and woven wire fences?

EXAM

T F 1. A dummy post is used to stretch barbed wire.

T F 2. Fencing staples are driven parallel to the grain.

T F 3. Wire stays are needed for suspension fences.

T F 4. The close-mesh end of woven wire goes on top of post.

T F 5. Compression fittings are used to join rolls of wire.

T F 6. Never use a tractor to stretch wire.

T F 7. Stretch wire until 1/3 of the tension curves are gone.

T F 8. Electric fences should be grounded every 500 feet.

9. Have a practical test in stretching both barbed wire and woven wire. Grade on:

   a. Tension
   b. Level
   c. Safety

UNIT - BUILDING FENCES

Lesson 4 - How do I build electric fences?

Objective: Upon the conclusion of the lesson, students will be able to install and build gates for electric fences.

Study Questions:

1. What tools and materials are needed to install electric fence posts and braces?
2. How are the posts and braces for electric fences installed?
3. What tools and materials are needed to install wire for electric fences?
4. How is the wire laid out and attached to electric fences?
5. What tools and materials are needed to build gates for electric fences?
6. How are the gates built?

References:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Transparencies
    a. TM-1: Electric Gates

UNIT - BUILDING FENCES

Lesson 4 - How do I build electric fences?

TEACHING PROCEDURE

A. Review

B. Motivation: Who has ever touched a live, electric fence? Have you seen an animal touch one? Who can tell me how the fence works?

C. Assignment

D. Supervised Study: Construct an electric fence in conjunction with the other types of fences. Set the electric wire at the bottom and explain the advantages of using electric wire.

E. Discussion

1. Have the tools available in the classroom for discussion purposes and demonstrate the proper and safe use of each tool.

   What tools and materials are needed to install electric fences, posts, and braces?

   1) Post driver
      a) Capped steel pipe--metal
      b) Sledge hammer--wood
   2) Axe
   3) Pliers
   4) Hammer

2. The posts for electric fences are similar to those used for other types of fences. The difference lies in the amount of strength needed in the posts and braces; an electric fence needs less strength than those used for other types of fences.

   How are the posts and braces for electric fences installed?

   1) Use permanent fence posts if available.
   2) Sharpen posts and drive into ground until firm.
   3) Cut brace to fit post.
   4) Mark point where brace rests on ground.
   5) Set first line post on mark and drive into ground.

6) Wedge brace between base of live post and top of anchor post.
7) Toe nail.
8) Repeat procedure at opposite end.
9) Space posts 40 feet to 50 feet apart.
10) Attach insulators 2/3 of animal height.
    a) Horses and cattle--30 inches to 36 inches
    b) Hogs--14 inches to 16 inches
    c) Pigs--6 inches to 8 inches
    d) Sheep--2 wires; 8 inches and 22 inches

3. Wire for electric fences is generally smooth, but barbed wire can be used. The wire can generally be stretched by hand to sufficient tension. Explain the use of each tool.

What tools and materials are needed to install wire for electric fences?

1) Claw hammer
2) Pliers (wire cutting)
3) Live posts
4) Braces
5) Live post insulators
6) Strain insulators
7) Wire clips
8) Insulated gate handle
9) Wire
10) Insulator fasteners

4. Demonstrate how wire is laid out and the methods of attaching the wire to the insulators. Set up dummy posts and let the students try attaching insulators and wire.

How is the wire laid out and attached to electric fences?

1) Fasten end of wire to end post strain insulator.
2) Unroll wire along the fence line using an unrolling device.
3) Pull wire by hand and attach to insulator.
    a) Wrap
    b) Commercial-type, line-wire clip
    c) Plain wire wrap
4) Splice wire as needed, western union splice.
5) Put extra loops in gullies or ditches.
6) Attach warning signs.

5. Have the material on hand to demonstrate how to make a gate for electric fences.

What tools and materials are needed to build gates for electric fences?

1) Pliers (wire cutting)
2) Live post insulators
3) Wire clips
4) Screen door spring
5) Insulated gate handle
6) Wire
7) Fasteners

6. The gate needs to be located at a normal entrance-exit point in order to be effective. This is because electric fences are hard to see and well-worn paths are easily followed. Use TM-1: Electric Gates.

How are the gates built?

1) Attach live post insulator to end post.
2) Splice wire to live wire.
3) Form 6-inch loop in wire and attach spring.
4) Repeat steps 1 and 2 at opposite post.
5) Attach wire to gate hook.

F. Summary

Place the gates for electric fences in spots with low livestock concentration and in places that are highly accessible to the farmers. Remember to install lines with enough clearance from the ground to prevent the animals from overstepping the wire. Expose a few head of livestock to the wire before turning large numbers of animals into an electrically fenced area.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. F
5. F

UNIT - BUILDING FENCES

Lesson 4 - How do I build electric fences?

EXAM

T F 1. Posts for electric fences need to be stronger than do posts for woven wire fences.

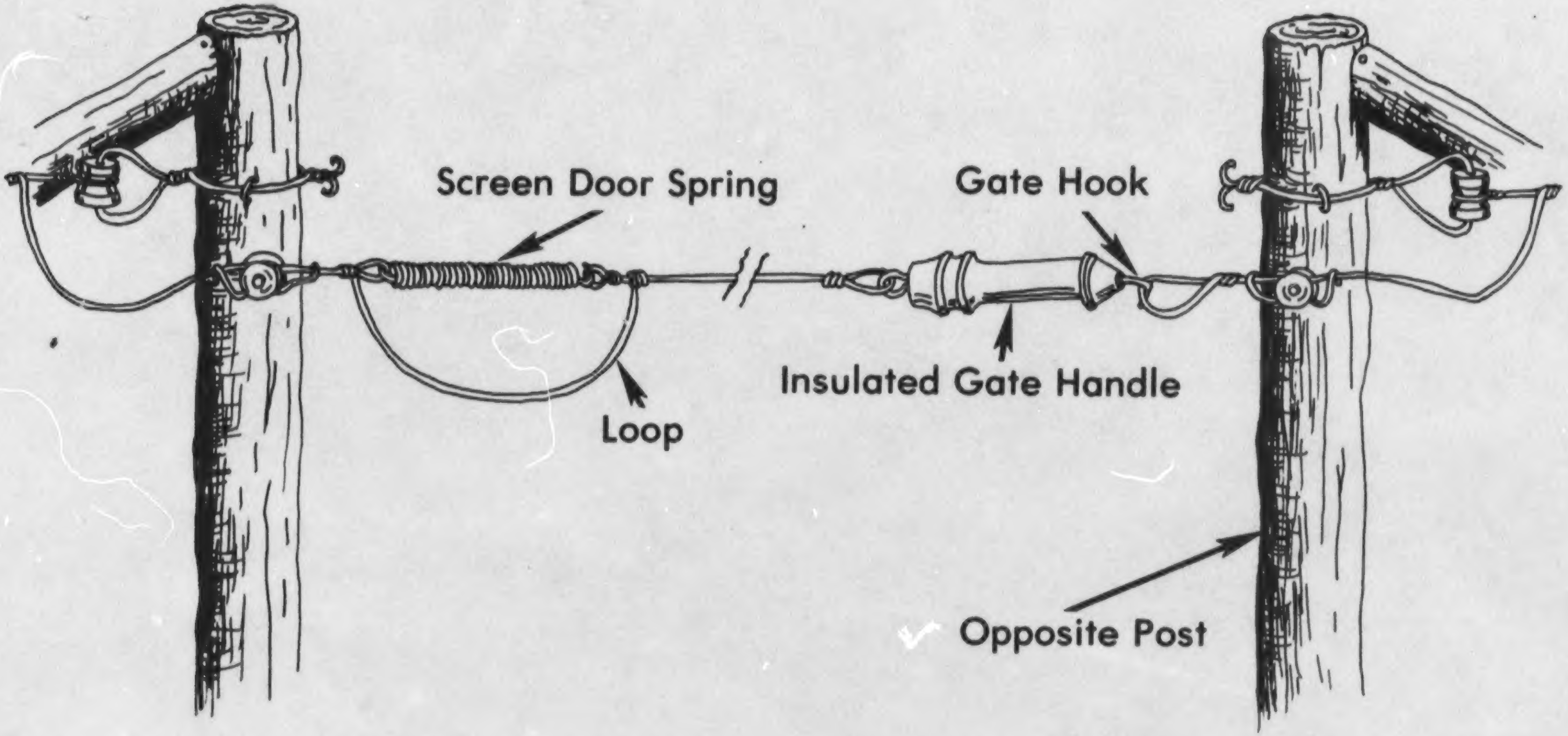
T F 2. Electric fence posts can be placed up to 50 feet apart.

T F 3. Cattle need fences 14 to 16 inches high.

T F 4. Electric wire should be attached directly to the post because wood is a good insulator.

T F 5. The spring in a gate wire acts as a coil which increases the charge on the gate.

Electric Gate


Screen Door Spring
Gate Hook
Insulated Gate Handle
Loop
Opposite Post

UNIT - BUILDING FENCES

Lesson 5 - How do I build cable fences?

Objective: Upon the conclusion of the lesson, students will be able to install cable fence springs, to stretch cable, and to secure cable.

Study Questions:

1. How are cable posts installed?
2. What tools and materials are needed to install and stretch cables and springs?
3. How are the cables and springs installed and stretched?

References:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Transparency
    a. TM-1: Cable Fence

UNIT - BUILDING FENCES

Lesson 5 - How do I build cable fences?

TEACHING PROCEDURE

A. Review lesson 1.

B. Motivation: How many students have actually seen a cable fence? How many have seen one installed?

C. Assignment

D. Supervised Study

E. Discussion

1. Cable fences are used in high confinement areas for livestock. The fences are expensive at first but very durable.

How are cable posts installed?

1) Use heavy posts.
    a) Corners are 6-inch diameter pressure treated wood or 3-inch OD (Outside Diameter) galvanized steel pipe set in concrete.
    b) Line is 5-inch diameter, treated wood or 3-inch OD pipe.
2) Follow procedures in lesson 2 for installation.

2. Cables are heavy and require high tension. Have the equipment used to stretch cable on hand.

What tools and materials are needed to install and stretch cables and springs?

1) Cable stretchers
2) Adjustable wrench
3) Drill and bits
4) Drill bits, 1/2 inch and 9/16 inch
5) Five-inch or 7-inch eye bolts
6) Three-eighth inch wire rope thimbles
7) Cable fence springs
8) Three-eighth inch wire rope
9) Three-eighth inch cable clamps

3. The installing and stretching needs to be done slowly and carefully to prevent trouble from wires snapping or posts cracking. Demonstrate outside to the class the procedure of installing and stretching cables. Allow for a snap clearance area to prevent injury.

How are the cables and springs installed and stretched?

1) Mark posts for drilling holes.
2) Drill holes.
    a) Wood--Drill 9/16-inch hole corners and 1/2-inch in line.
    b) Steel--Drill 3/8-inch corner and in line.
3) Thread cable through holes or eye bolts.
4) Hook spring into eye bolt at corner.
5) Make loop in cable at spring end with thimble.
6) Secure loop with two 3/8-inch cable clamps.
7) Hook loop to spring.
8) At other end of fence, attach cable stretcher.
9) With cable tight, wrap loose end around post and clamp.
10) Adjust tension.
11) Repeat steps with other cables. TM-1

F. Summary

Cable is good for confinement feeding operations due to cable strength and low maintenance of cable.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. T
5. F

UNIT - BUILDING FENCES

Lesson 5 - How do I build cable fences?

EXAM

T F 1. A 6-inch diameter wood post is recommended for a cable fence.

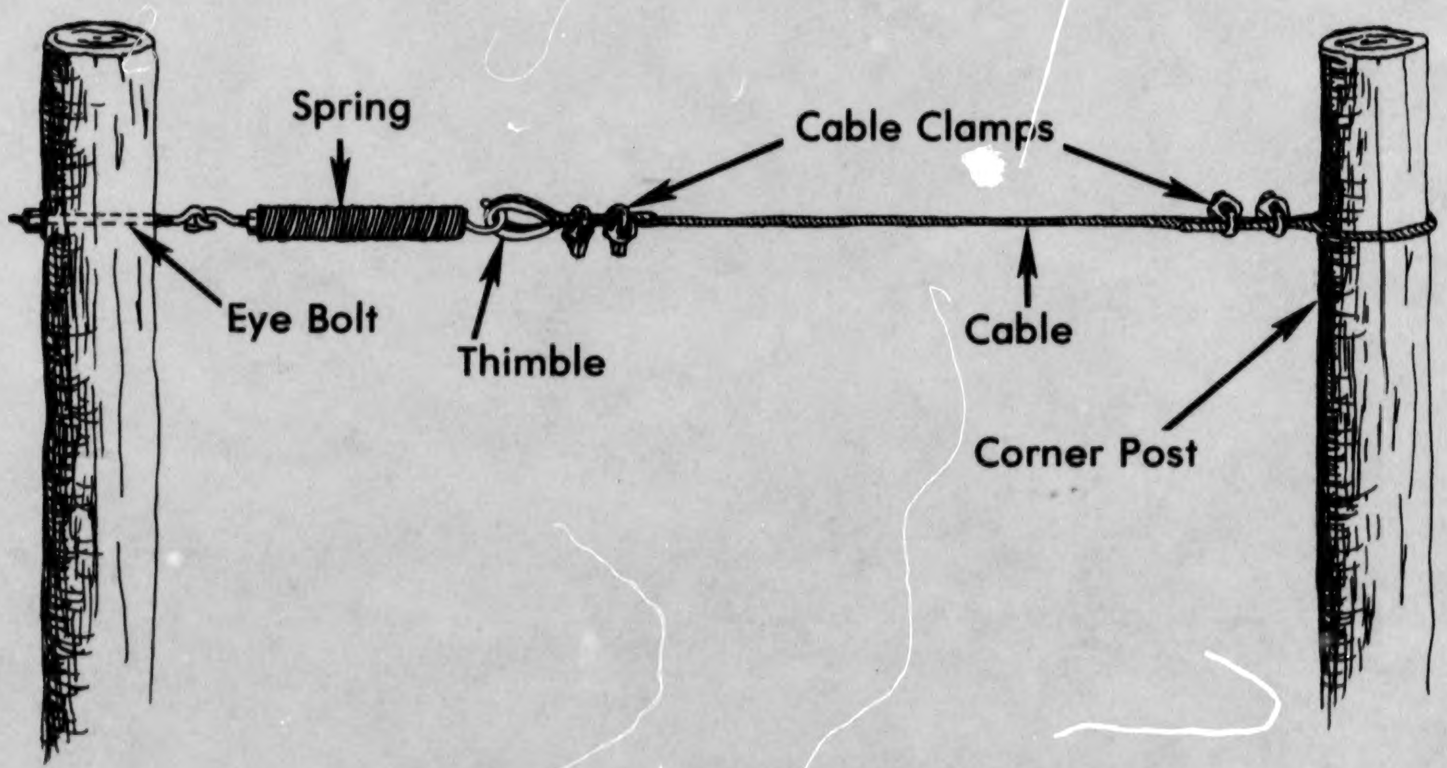
T F 2. Three-inch OD pipe is the size of pipe to use for cable fences.

T F 3. Eye bolts are used on the line posts to add stability.

T F 4. Three-eighth inch holes are drilled in pipe posts.

T F 5. Tension is adjusted with the cable stretcher.

Cable Fence



Spring
Cable Clamps
Eye Bolt
Thimble
Cable
Corner Post

403

TM-1

UNIT - BUILDING FENCES

Lesson 6 - How do I build welded-wire panel fences?

Objective: Upon the conclusion of the lesson, students will be able to lay out fence lines, install posts, and hang and fasten panels.

Study Questions:

1. What tools and materials are needed to install posts for panel fences?
2. How is a fence line laid out?
3. How are the posts installed?
4. What tools and materials are needed to hang and fasten panels?
5. How are the panels hung?
6. How are the panels fastened to the posts?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 6 - How do I build welded-wire panel fences?

TEACHING PROCEDURE

A. Review setting posts.

B. Motivation: Have any of the students seen a welded-wire fence panel made? Is it as strong as woven-wire?

C. Assignment

D. Supervised Study

E. Discussion

1. Have the tools needed at hand; the process is similar to other fencing methods.

   What tools and materials are needed to install posts for panel fences?

   1) Hole digger
   2) Tamping bar
   3) Shovel
   4) Axe
   5) Stakes
   6) String
   7) Wood posts
   8) Concrete ingredients (See reference.)
   9) Steel tape

2. Welded-wire fences will be laid out in four-sided configurations on most occasions because of the inflexibility of the panels. Mark off a lot and check for squareness.

   How is a fence line laid out?

   1) Drive stake at one corner.
   2) Measure from first stake to next corner; try to use 16-foot divisions.
   3) Drive stake.
   4) Do likewise for other corners.
   5) Check diagonals to check squareness.
   6) Stretch strings to align posts.
   7) Measure increments of 8 feet or 5 1/3 feet; stake for posts.

3. Posts must be aligned and squared before permanently being set.

   How are the posts installed?

   1) Dig post holes.
   2) Set posts and recheck distance.
   3) Pour concrete collar.

4. Gather the tools needed and practice using the drills and nails.

   What tools and materials are needed to hang and fasten panels?

   1) Claw hammer
   2) 10d nails
   3) Adjustable end wrench
   4) J-bolts 3/8 inch x 7 inch; nuts & washers
   5) Three-eighth inch brace and bit
   6) Welded wire panels, 1/4-inch wire in 16-foot panels; 34 inches--hogs; 52 inches--cows

5. Placement of the panels will vary with the slope of the land. Place the panels loosely before securing them to avoid errors.

   How are the panels hung?

   1) Drive nails near top of posts where panels meet.
   2) Hang the panels loosely on nails and position them.
   3) On sloping land, step down adjacent panels.

6. Fastening requires skills that need to be practiced before attempting. Demonstrate drilling, imbedding, and tightening in scrap wood.

   How are the panels fastened to the posts?

   1) Drill 3/8-inch hole for each fastener--top, middle, bottom.
   2) Notch post on outside (nut side).
   3) Place the J-bolt into holes.
   4) Imbed hook end of J-bolt into post.
   5) Place washer and nut on bolt; then tighten.
   6) Cut off projecting ends of bolt.
   7) Repeat procedure with each bolt.

F. Summary

Welded-wire is limited in open country and should be limited to feed lots or small home lots.

G. Evaluation

Answers to Exam

1. F
2. T
3. T
4. F
5. T

UNIT - BUILDING FENCES

Lesson 6 - How do I build welded-wire panel fences?

EXAM

T F 1. Welded-wire fences are easily adapted to open country.

T F 2. Sixteen foot divisions are common when planning for a welded-wire fence.

T F 3. A concrete collar is needed for posts because of the stress of confined livestock.

T F 4. Notching the post on the inside provides a stronger hold for the welded-wire panel.

T F 5. Quarter-inch wire is used in welded-wire panels.

UNIT - BUILDING FENCES

Lesson 7 - How do I build board fences?

Objective - Upon the conclusion of the lesson, students will be able to install board fences.

Study Questions:

1. What tools and materials are needed to install posts and braces?
2. How is the fence staked out?
3. How are the posts installed?
4. What tools and materials are needed to install the boards?
5. How are the boards laid out, sawn, and attached to posts?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 7 - How do I build board fences?

TEACHING PROCEDURE

A. Review fence layout.

B. Motivation: Where are board fences used? Is it easier to install a board fence than a wire fence? How long will a board fence last?

C. Assignment

D. Supervised Study: Construct a board fence corner.

E. Discussion

1. Have the tools on hand that are needed for setting the posts. Demonstrate the proper use of each tool.

   What tools and materials are needed to install posts and braces?

   1) Post hole digger or shovel
   2) Tamping bar
   3) Carpenter's level
   4) Six-foot rule
   5) Gage pole
   6) Posts 4 inches x 4 inches x 7 feet or 8 feet
   7) Axe
   8) Stakes

2. Layout is similar to the methods used in other areas. Problems are that the boards are stiff and inflexible.

   How is the fence staked out?

   1) Drive stake at each end of fence and stretch line between stakes.
   2) Measure off post spacings.
   3) Use 8-foot gage pole for rest of spacing.

3. Installing the posts relies on levelings, squareness, and hole depth. Practice setting posts in class.

   How are the posts installed?

    1) Dig holes 2 1/2 feet deep for a 7-foot post.
    2) Place posts with flat surface on side where boards are nailed.
    3) Set end post.
    4) Set other end.
    5) Set line post on each major rise or depression.
    6) Extend cord along top of each post.
    7) Set remaining posts so top edge touches the string.

4. Have the tools for installing the fence available and demonstrate the use of each tool.

    What tools and materials are needed to install the boards?

    1) Saw
    2) Claw hammer
    3) Try square
    4) Pencil
    5) Boards
    6) Two 8-foot fence panels
    7) One-half pound 10d common nails
    8) Straight panel woods
    9) Diamond panel woods

5. Practice the skills of squaring boards and cutting them to length before nailing the boards. Then practice nailing boards in both the flat and vertical positions. Plan carefully before nailing anything.

    How are the boards laid out, sawn, and attached to posts?

    1) Layout boards along fence line.
    2) Place 16-foot board (6-inch width) at top of first 2 spans for rough measurement and mark for sawing.
    3) Saw ends of board.
    4) Apply wood preservatives to cut surface.
    5) Nail boards to all 3 posts with a minimum of 2 nails to each post.
    6) Measure second board from first post to second post center.
    7) Space and nail boards.
        a) Ten inch straight
        b) Twenty-one inch diamond
    8) Measure, saw, and nail remaining boards.
        a) Straight spacing between boards: 10-8-6-5 inches
        b) Diamond spacing between boards: 21-8-6 inches

9) Install fascia boards.
   - a) Saw top of posts even with top board.
   - b) Apply preservative to post top.
   - c) Place fascia boards on top (16 feet) and mark for cutting to centers.
   - d) Square and saw ends.
   - e) Nail board in position.
   - f) Measure and mark vertical fascia boards.
   - g) Square and saw board.
   - h) Apply preservative to it.
   - i) Nail fascia board in position.

F. Summary

Board fences can be expensive to build and can have a short lifespan. Layout is dependent upon available board length and, therefore, problems occur in the uniformity of the length of the wood. Possible warping of the wood is another problem. Board fences are usually limited to areas requiring high strength or aesthetic beauty (corrals, along driveways, or along roads).

G. Evaluation

Answers to Exam

1. T
2. T
3. T
4. T
5. T

UNIT - BUILDING FENCES

Lesson 7 - How do I build board fences?

EXAM

T F 1. Four-inch x 4-inch posts are common for building board fences.

T F 2. Posts should be set 2 1/2 feet in the ground.

T F 3. Posts can be aligned easily with the top string.

T F 4. Boards are measured and cut to fit centers.

T F 5. The spacing of the boards should be reduced as they are placed closer to the ground.

UNIT - BUILDING FENCES

Lesson 8 - How do I build wood rail fences?

Objective: Upon the conclusion of the lesson, students will be able to install posts and rails and zig-zag rail fences.

Study Questions:

1. What tools and materials are needed to install posts and rails?
2. How are the holes drilled into the posts?
3. How are the rail ends tapered?
4. How are the posts and rails set?
5. What tools and materials are needed to install zig-zag rail fences?
6. How are the fence lines staked out?
7. How are the rails attached?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 8 - How do I build wood rail fences?

TEACHING PROCEDURE

A. Review staking in lesson 7.

B. Motivation: How many students have seen rail fences? How easy is it to build this type of fence?

C. Assignment

D. Supervised Study: Lay out a wood rail fence to show its difficulty in planning and arranging.

E. Discussion

1. Have the tools on hand when discussing the equipment used.

   What tools and materials are needed to install posts and rails?

   1) Post hole digger
   2) Tamping bar
   3) Carpenter's level
   4) Six-foot rule
   5) Heavy cord
   6) Gage pole
   7) Wood drill
   8) Chisel
   9) Wood and 16d nails

2. Staking is done as in lesson 7, spacing to match the length of the rails. The posts need holes into which to put the ends of the rails. Practice drilling in scrap first.

   How are the holes drilled into the posts?

   1) Locate place for drilling.
      a) Two and one-half feet into ground
      b) Minimum of 6 inches from top of post
      c) Split difference evenly with number of rails.
   2) Drill holes in posts--circular first.
   3) Chisel out holes to accommodate rails. Corners have holes at 90° angles.

3. The ends of the rails need to be tapered to allow two rails per hole. Cover the safety of using an axe before trying to taper rails; then demonstrate.

How are the rail ends tapered?

1) Mark the rail ends to approximate size of hole in post.
2) Taper the rail with axe for end 10 inches of rail.

4. After the posts are drilled and the rails tapered, the posts need to be set to match the rail lengths. Level the posts carefully.

How are the posts and rails set?

1) Dig hole 2 1/2 feet deep.
2) Plumb post and tamp.
3) Insert rail loosely in end post and locate next post hole.
4) Dig next post hole and slide rails into slots.
5) Plumb post and back fill.
6) Secure rails by nailing.

5. Have the tools on hand when discussing this question. This method was used extensively in colonial times.

What tools and materials are needed to install zig-zag rail fences?

1) Axe
2) Two-foot stakes and 5-foot stakes
3) Measuring cord and tape
4) Rails
5) Chalk

6. The zig-zag fence line is more difficult to set up than a regular straight one. Basic math is needed to solve the angle problems. Work out the math before starting to build the fence.

How are the fence lines staked out?

1) Determine critical boundary of one side of fence.
2) Clear fence area.
3) Drive stakes one foot inside critical boundary for overhang.
4) Stretch cord between stakes.
5) Establish width of fence.
    a) Measure average length of rails.
    b) Subtract 2 feet.

        c) Divide by 2.
    6) Drive stakes along second fence boundary opposed to steps 3 and 4.
    7) Stretch cord between stakes as in step 6.

7. Stacking the rails must be done methodically to give an even look. Watch the crossover points. This can be demonstrated using twigs or other small wood products.

   How are the rails stacked?

   1) Mark rail one foot from each end.
   2) Lay rail on one Cord line at point marked.
   3) Lay rail on opposite cord line at other point marked.
   4) Lay second rail over first rail at point marked.
   5) Lay other end of second rail on opposite line at point marked.
   6) Continue laying other bottom rails.
   7) Drive 5-foot stakes on the outside of the crossover points; plumb stakes.
   8) Stake remaining rails.

F. Summary

Wood-rail fences are probably the most attractive of the fence types, but are not well suited for all types of livestock. Also, rail fences are expensive and time consuming to install. Layout is based on rail length, and the proper placement of the posts can be difficult due to the way the rails are secured in the posts.

G. Evaluation

Answers to Exam

1. F
2. T
3. F
4. T
5. F

UNIT - BUILDING FENCES

Lesson 8 - How do I build wood rail fences?

EXAM

T F 1. The gage pole is used to measure the height of the post.

T F 2. Rail ends are tapered 10 inches from the end for a smoother fit.

T F 3. The width of fence of a zig-zag fence with 16-foot rails is 8 feet.

T F 4. The five-foot stake is used to secure the ends of the crossed rails.

T F 5. When installing post and rail fences, the line post holes are dug before the rails are put in place.

UNIT - BUILDING FENCES

Lesson 9 - How do I build chain link fences?

Objective: Upon the conclusion of the lesson, students will be able to lay out fence lines, set posts, stretch fabric, and attach fabric to the posts.

Study Questions:

1. What tools and materials are needed to lay out a fence line and set posts?
2. How is a fence line laid out for a chain link fence?
3. How are posts set for a chain link fence?
4. What tools and materials are needed to stretch and attach a chain link fence?
5. How are the posts prepared for hanging chain link fence fabric?
6. How is the chain link fabric hung, stretched, and fastened?
7. How is a chain link gate hung?

Reference:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00

UNIT - BUILDING FENCES

Lesson 9 - How do I build chain link fences?

TEACHING PROCEDURE

A. Review

B. Motivation: Where are chain link fences used? Are they adaptable to confining large livestock? How does the cost compare with other fences?

C. Assignment

D. Supervised Study

E. Discussion

1. The layout and setting of equipment is similar to the other fencing procedures except for final anchoring. Have the hardware present.

   What tools and materials are needed to lay out a fence line and set posts?

   1) Digger
   2) Tamping bar
   3) Level
   4) Axe
   5) Stakes and string
   6) Concrete or post driver and anchors
   7) Posts

2. Divide fence run as in previous lessons.

   How is a fence line laid out for a chain link fence?

   1) Locate property lines.
   2) Drive stakes on line and run string between them.
   3) Locate ends, corners, and gates.
   4) Determine line post locations.
      a) Without top rail, 8 feet apart
      b) With top rail, 10 feet apart
   5) Drive stakes at posts' locations.

3. Setting the posts must be done carefully because of the tremendous load on the poles when the wire is attached. Set securely.

   How are posts set for a chain link fence?

1) Determine the height of posts above ground.
    a) Tops of posts 2 inches above fabric on terminal posts
    b) Tops of posts 2 inches below the top of fabric on line posts
2) Mark each post at ground level with chalk.
3) Set posts--concrete
    a) Dig post holes.
    b) Check depth with post chalk mark.
    c) Pour concrete to 1-foot depth.
    d) Set post.
    e) Check post for vertical alignment.
    f) Fill hole with concrete.
4) Set posts--steel anchors
    a) Set post in position.
    b) Place post driver over post.
    c) Start post into ground.
    d) Check alignment.
    e) Complete driving.
    f) Remove soil 4 inches deep with an 8-inch diameter from post.
    g) Drop metal locking ring over post.
    h) Place 3 anchors straight up between ring and post.
    i) Tilt anchors away from post.
    j) Drive anchors.
    k) Tighten nut on locking ring bolt.
    l) Cover with dirt.

4. Gather all of the tools and materials needed to stretch and attach the fence and explain the use of each tool and material to the class. If facilities exist, demonstrate use of tools and materials.

What tools and materials are needed to stretch and attach a chain link fence?

1) Tension bands
2) Tie wires
3) Gate hinges
4) Gate latch
5) Post caps
6) Rail end bands
7) Top rail ends
8) Loop caps
9) Top rail couplings
10) Fence stretcher and stretcher bar
11) Pliers
12) Adjustable wrench
13) Socket wrench
14) Hacksaw and bolt cutters

5. Go over the types of attaching equipment and how they are used on the posts.

   How are the posts prepared for hanging chain link fence fabric?

   1) Attach tension bands to terminal posts.
   2) Attach rail end fittings to rail end bands.
   3) Install post caps.
   4) Attach loop caps to top of line posts.
   5) Thread top rail through loop cap.
   6) Join top rail sections as needed.
      a) Swedged-end
      b) Plain-end couplings
   7) Insert end of the top rail into recess in rail end, fitting to the terminal post.

6. Be sure to get the wire tight before tying end tight. Tension may vary according to the terrain.

   How is the chain link fabric hung, stretched, and fastened?

   1) Unroll fabric along fence line.
   2) Thread tension bar through end of fabric and tension bands.
   3) Tighten bolts on tension bands.
   4) Thread stretcher bar in fabric 2 feet from terminal post at opposite end.
   5) Attach fabric to top rail with loose tie wire between each line post.
   6) Attach stretcher.
   7) Apply tension to tauntness without distortion.
   8) Cut fabric to proper length.
   9) Thread tension bar through end of fabric and tension bands on terminal post.
   10) Tighten tension band bolts.
   11) Release tension on stretcher.
   12) Repeat procedure as needed.

7. The final step is to provide ways to get in and out of the fenced area. Gates for people and the largest machinery to enter the area need consideration.

   How is a chain link gate hung?

   1) Attach hinges to gate.
   2) Loosen female hinges on gate frame and slip over male hinges.

3) Tighten securely.
4) Attach gate latch.
5) For double swing gates, provide a ground drop pipe latch.

F. Summary

Chain link fences are used in areas of high security because of their strength. Expense of chain link fences contribute to their limitation in use. Also, the stretching and the weight of the chain link fabric limit usage.

G. Evaluation

Answers to Exam

1. T
2. T
3. F
4. F
5. T

330

UNIT - BUILDING FENCES

Lesson 9 - How do I build chain link fences?

EXAM

T F 1. Chain link fences need a heavier anchoring on posts than other fences.

T F 2. A top rail allows for a wider spacing of posts.

T F 3. Posts should protrude 6 inches above the wire fabric.

T F 4. Loop caps go on all terminal posts for strength.

T F 5. A stretcher bar is needed for even pull to be applied.

UNIT - BUILDING FENCES

Lesson 10 - How do I build gates?

Objective - Upon the conclusion of this lesson, students will be able to build metal, wood, and temporary gates.

Study Questions:

1. What tools and materials are needed to build metal gates?
2. How is a metal gate frame built and wire applied?
3. How is a metal gate hung?
4. What tools and materials are needed to build wood gates?
5. How is the gate frame built?
6. How is the wood gate hung?
7. What tools and materials are needed for a temporary gate, and how is it built?

References:

1. Building Fences, by AAVIM, available through IML, 10 Industrial Education Building, University of Missouri-Columbia, Columbia, MO 65211 $3.00
2. Transparencies
    - a. TM-1: Metal Gates
    - b. TM-2: Wood Gates
    - c. TM-3: Temporary Gate

UNIT - BUILDING FENCES

Lesson 10 - How do I build gates?

TEACHING PROCEDURE

A. Review types of fences studied.

B. Motivation: How easy is it to build a gate? Are wood gates harder to build than metal ones? What factors (stresses) need to be considered when building a gate?

C. Assignment

D. Supervised Study: Build a gate out of wood or metal and hang the gate to a post.

E. Discussion

1. Have the tools available for demonstration purposes before starting the explanation of each tool. Push safety! Use TM-1: Metal Gates.

   What tools and materials are needed to build metal gates?

   1) Three-eighth inch electric drill
   2) Brace and 5/8-inch bit
   3) Five-eighth inch die and threader
   4) Welder
   5) Adjustable wrench and pliers
   6) Hammer, vise, grinder
   7) Framing square, hacksaw, soapstone
   8) For a gate 12 foot wide x 52 inches high
      a) Two pieces 3/4-inch pipe 12 feet long
      b) Three pieces 3/4-inch pipe 4 feet long
      c) One piece 3/4-inch pipe 3 feet 10 inches long
      d) Two pieces 3/4-inch pipe 3 inches long
      e) One piece 1-inch pipe 4 feet long
      f) One piece 1/4-inch x 1-inch flat steel 9 feet long
      g) Thirteen feet of 47 inch stock and field fence
      h) Two pieces 5/8-inch steel rod 15 inches long
      i) Two 5/8-inch flat washers
      j) Two 3/8-inch x 5-inch bolts with washers and nuts
      k) Chain and harness snap

2. Layout of the metal gate is important. The gate must be squared carefully to insure a tight fit. Practice welding pipe before attempting a gate.

How is a metal gate frame built and wire applied?

1) Lay out and weld frame.
    a) Use 1-inch pipe for hinge side.
    b) Use 3/4-inch pipe for rest of sides and support.
2) Weld hinges to frame 6 inches from end on outside of frame.
3) Weld 3/8-inch bolts to frame 12 inches from ends to 1-inch pipe on inside of frame.
4) Weld the brace.
5) Mount the wire-stretcher pipe on 3/8-inch bolts.
6) Attach one end of wire to latch end of frame.
7) Attach other end of wire to stretcher pipe on the hinge end of the frame.
8) Stretch the wire by tightening the nuts on the bolts passing through the tension pipe.

3. Carefully hang the metal gate to the posts. This requires measuring the distance between hinges and the distance from the bottom of the gate to the ground.

How is a metal gate hung?

1) Prepare the stationary (male) hinge.
    a) Bend a 5/8-inch by 15-inch rod "L" shaped.
    b) Short end must be 3 inches; long end must be 12 inches.
    c) Weld a 5/8-inch washer 1 inch from short end.
    d) Thread 3 inches of long end.
2) Drill holes for hinges; use the gate to measure.
3) Engage hinges, both bolts on outside of hinges.
4) Mount the gate.
5) Install chain latch.

4. Have the tools available for demonstration purposes. Demonstrate the proper and safe way to use each tool. TM-2: Wood Gates.

What tools and materials are needed to build wood gates?

1) Three-eighth inch electric drill.
2) Three-eighth inch and 5/8-inch drill bits
3) Adjustable wrenches
4) Handsaw or electric saw
5) Rule and pencil
6) Claw hammer
7) Framing square

8) Materials for a 4 foot x 12 foot gate
   a) Cable brace 1 3/8 inch x 15 foot
   b) Horizontal boards 6 feet 1 inch x 6 inches x 12 feet
   c) Upright boards 6 feet 1 inch x 6 inches x 4 feet
   d) Braces 4 feet 1 inch x 6 inches x 7 feet
   e) Clevis 1/4 inch x 2 inches (or turnbuckle)
   f) Two eyebolts--5/8 inch x 12 inches
   g) Latch--1 inch x 3 inches x 18 inches
   h) Four hinge support blocks--1 inch x 6 inches x 30 inches
   i) Twenty-two carriage bolts--3/8 inch x 2 3/4 inch; eight carriage bolts--3/8 inch x 3 1/4 inch
   j) Latch brace--1 inch x 6 inches x 27 inches
   k) Machine bolt--5/8 inch x 3 1/2 inches
   l) Hinge strap 1/4 inch x 2 inches
   m) Two male hinge bolts--5/8 inch x 15 inches
   n) Three pounds 10d common nails

5. Careful layout is necessary to have a square gate that will fit the opening intended. A gig can be used to facilitate building if several gates are to be built.

How is the gate frame built?

1) Lay out the gate frame.
   a) Use 1-inch x 6-inch boards, 2 boards on ends; sandwich bottom and top boards.
   b) Nail the 4-inch upright end boards to the 12-foot boards.
   c) Center and nail the middle 12-inch board to frame.
   d) Center middle 4-foot board and nail.
2) Install diagonal braces--7 foot boards.
3) Install hinge support blocks.
4) Install latch and latch brace.
5) Install the latch handle.
6) Install bolts for hinges.

6. Wood gates are hung in a similar fashion to the metal gates with emphasis on support for the gate. Measure carefully and be sure to level the gate for ease in opening and closing.

How is the wood gate hung?

1) Install female hinges on gate.
2) Drill holes in gate post for male hinges.
3) Engage hinges.
4) Mount gate to post.
5) Install cable brace.
6) Adjust tension on brace cable to level gate.

7. Sometimes a temporary opening is needed in a fence. These gates are used where only a little stress will be put on the gate at one time.

   What tools and materials are needed for a temporary gate, and how is it built?

   1) Tools needed
      a) Claw hammer
      b) Wire cutting pliers
      c) Axe
   2) Materials needed
      a) Pole--2-inch diameter, 6-feet long
      b) Fence wire
      c) Staples (wood posts)
      d) Wire clamps (metal posts)
   3) Cut a pole the same height as fence post.
   4) Attach wires to pole.
   5) Make upper and lower wire loop on attachment post.
   6) Test assembly for tension and ease of opening and closing. TM-3

F. Summary

Gate building is an important part of the fence building process. Without a well-constructed gate, the ease of moving livestock can be greatly hampered.

G. Evaluation

Answers to Exam

1. T
2. T
3. T
4. F
5. F

UNIT - BUILDING FENCES

Lesson 10 - How do I build gates?

EXAM

T F 1. Larger pipe used on the hinge side of a metal gate to reinforce the hinges.

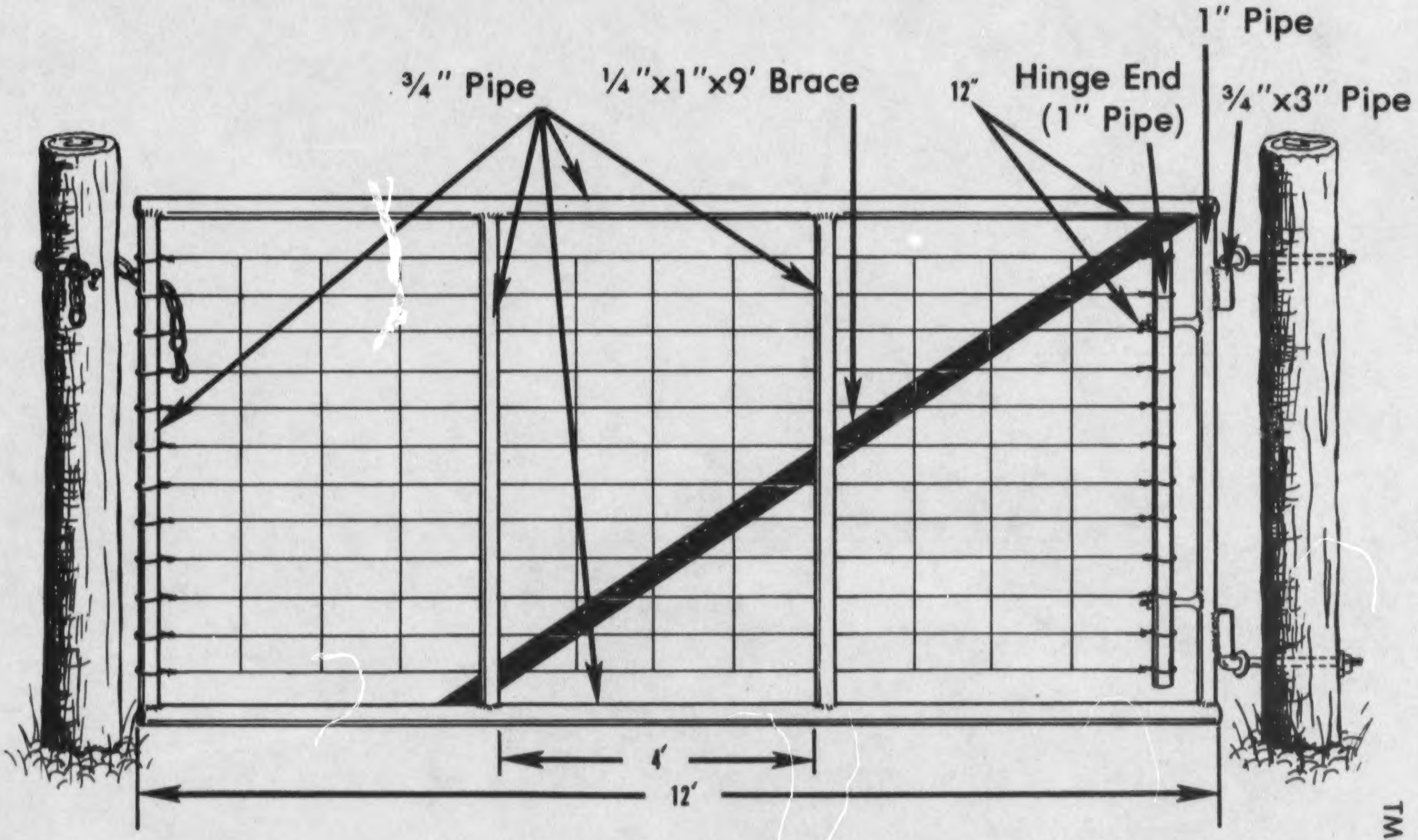
T F 2. Bracing is used to prevent warping in wood gates.

T F 3. The cable brace on a wood gate is used to relieve the stress on the hinges.

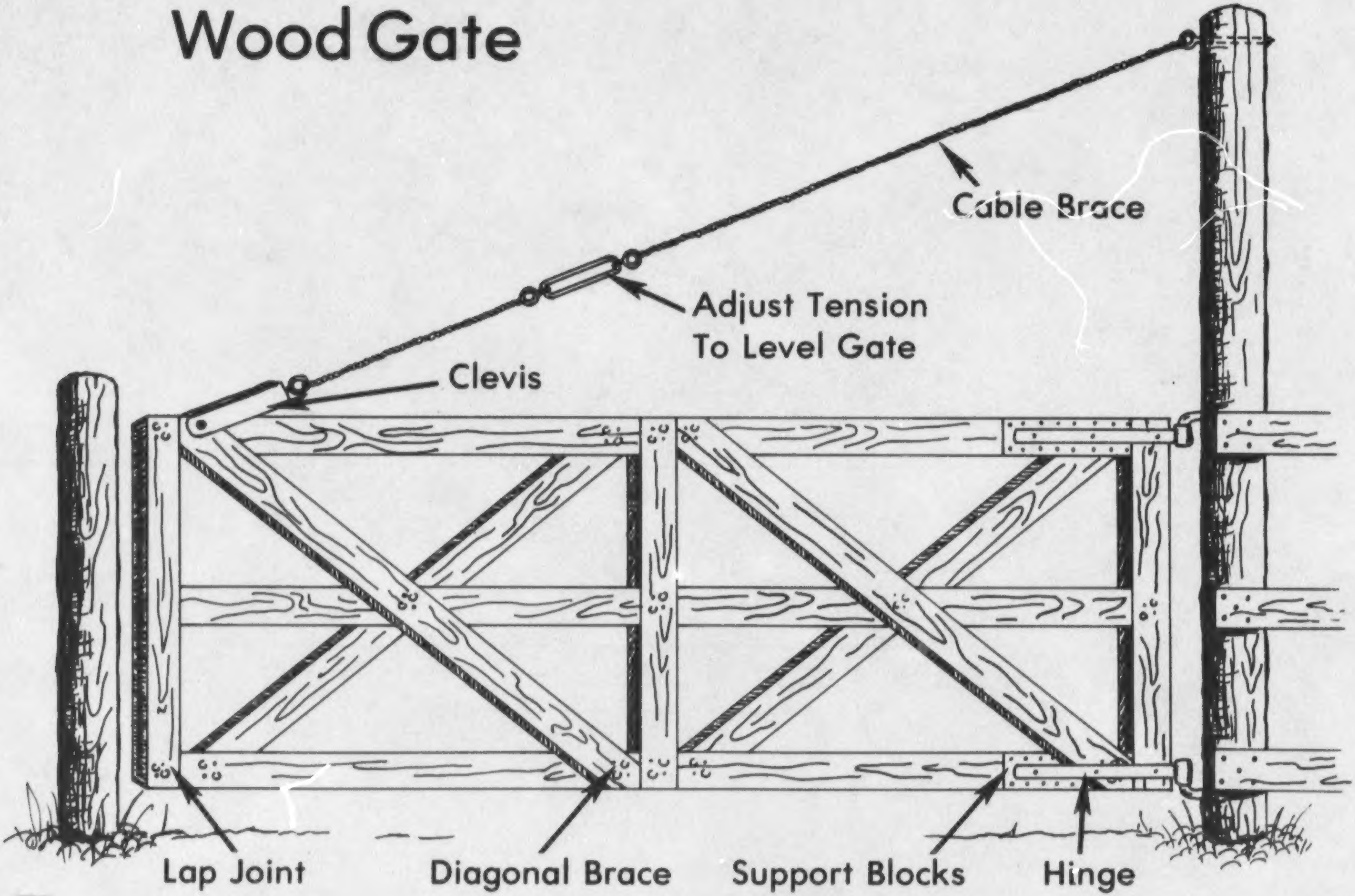
T F 4. The male part of the hinges are both turned up to make hanging the gate easier.

T F 5. Temporary fences should be able to stop the forward push of the largest animal in the fenced area.

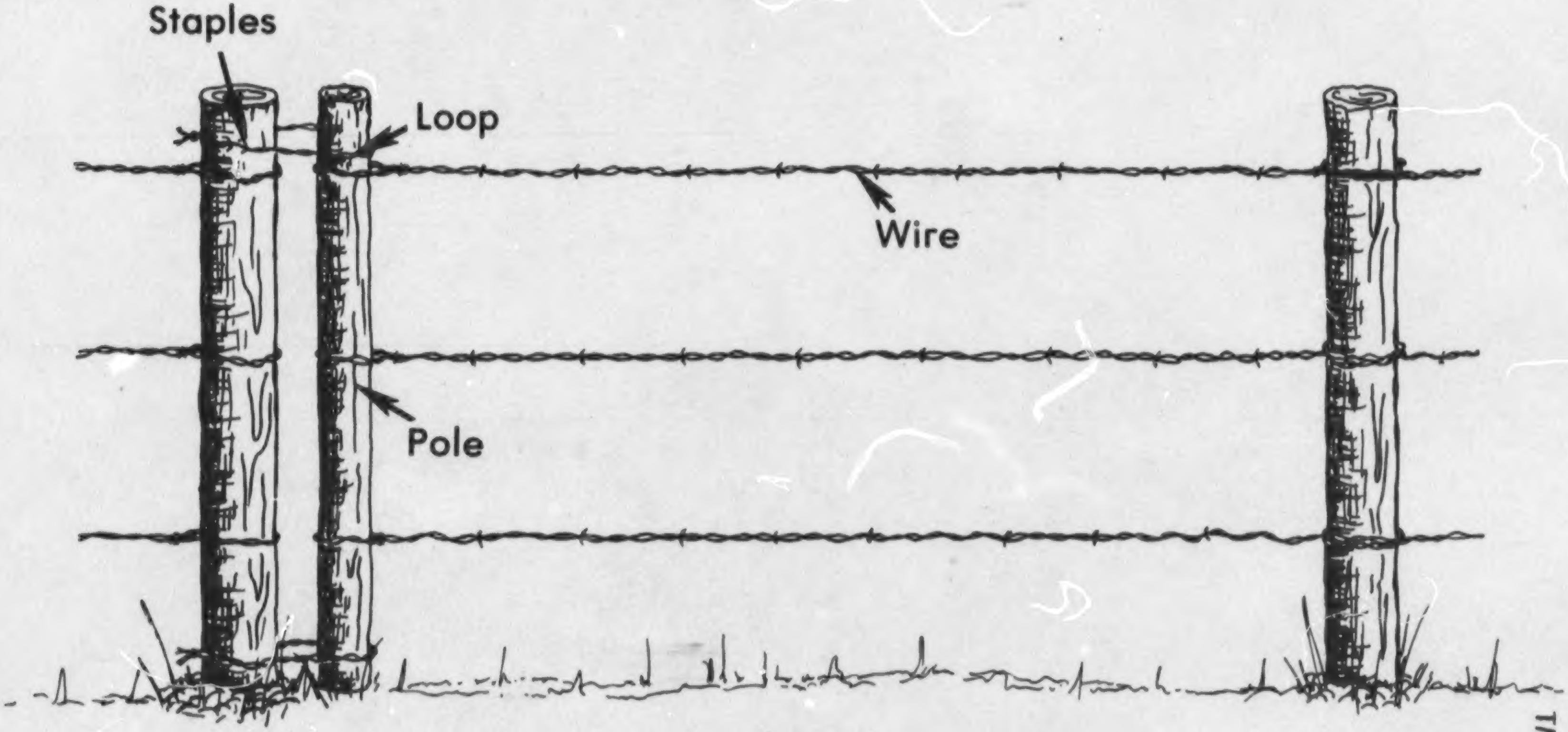
Metal Gates


¾" Pipe
¼"x1"x9' Brace
12"
Hinge End (1" Pipe)
1" Pipe
¾"x3" Pipe
4'
12'

Wood Gate


Cable Brace
Adjust Tension
To Level Gate
Clevis
Lap Joint
Diagonal Brace
Support Blocks
Hinge

Temporary Gate


Staples
Loop
Wire
Pole

TM-3

UNIT - BUILDING FARM FENCES

LABORATORY EXERCISE

Objective: Upon the conclusion of the laboratory exercise, students will be able to install a wood and steel anchor-and-brace assembly for woven or barbed wire fences.

Tools Needed:

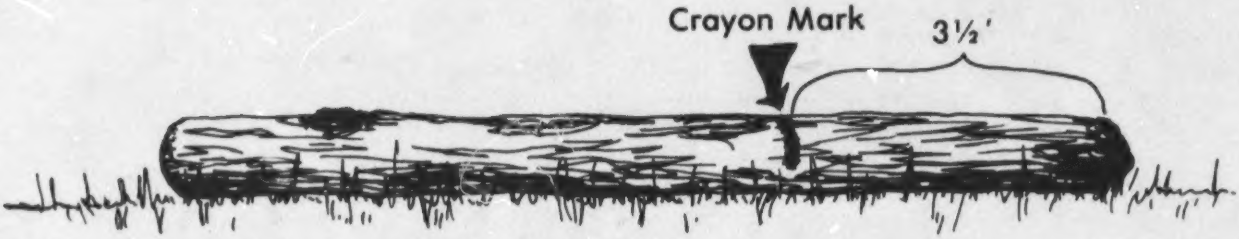
1. Post hole digger
2. Tamping bar
3. Spud
4. Axe
5. Spade
6. Claw hammer
7. Handsaw
8. Wire splicer
9. Brace and bit (1/2 inch)
10. Carpenter's level
11. Six-foot rule
12. Marking crayon
13. Ball of twine
14. Fencing pliers

Materials Needed:

1. Steel dowels (1/2 inch x 4 inches) (2 per brace)
2. Fencing staples
3. Brace wire
4. Eighteen- to 24-inch piece of pipe or wood
5. Two posts and one brace pole

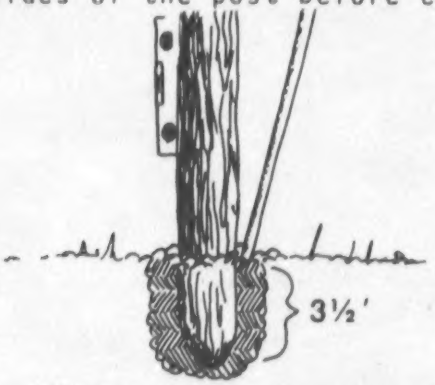
Procedure:

Step 1: Mark on each post the depth it must go into the ground. Setting depth should be a minimum of 3 feet 6 inches. Mark this depth using a 6-foot rule and the marking crayon. If the pole is tapered, measure the 3 1/2 feet from the larger end.



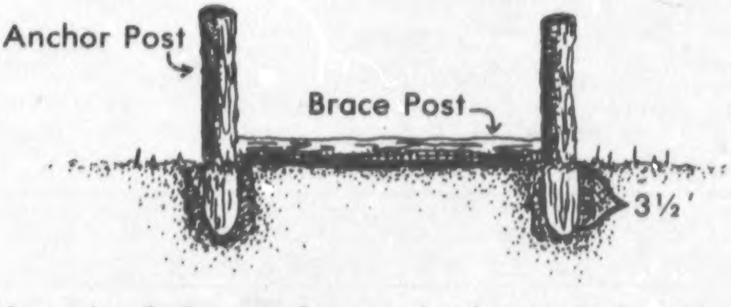
Step 2: Using the post hole digger or a tractor-mounted power digger, dig a 12-inch diameter hole 3 1/2 feet deep. Measure with the rule.

Step 3: Set the post in the hole, checking the depth mark on the post; and tamp the soil around the post. Tamp in layers of 4 to 6 inches to insure tight compaction. Use the tamping bar and spud. After each layer is compacted, check the post for plumb with the carpenter's level. Check all sides of the post before continuing.



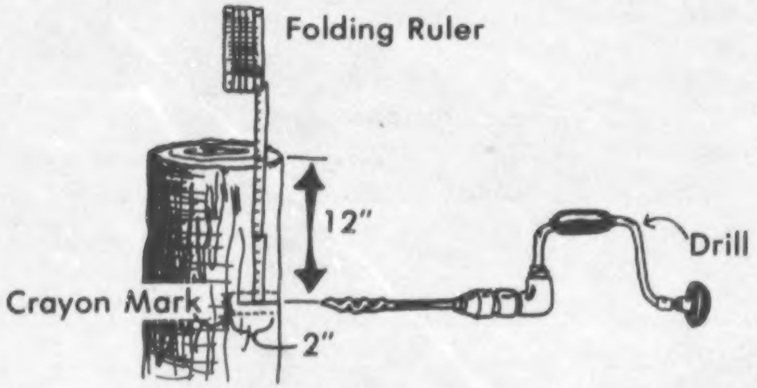
Step 4: Measure the distance from the first post to the second post, using the brace post that will be placed between them. The brace post should be at least 8 feet in length. Dig a hole for the second post (also called the brace post). See Step 2.

Step 5: Place the brace post into the hole but do not tamp the soil around it yet. Check to see if the horizontal brace will fit between the posts. If not, expand the brace post hole.

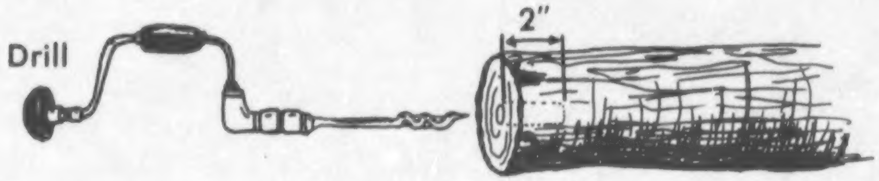


Step 6: Using the 6-foot rule, mark the spot for the dowel hole 12 inches from the top of the anchor post. Use the marking crayon to mark the drilling spot.

Step 7: Bore a hole 2 inches deep using the brace and bit the same diameter as the steel dowel pin, 1/2 inch. Be sure the hole is facing the brace post.



Step 8: Find the center of the horizontal brace end and bore a hole 2 inches deep in both ends. The diameter should be the same. Do not drill too deep. Use a stop or mark the bit to check depth.



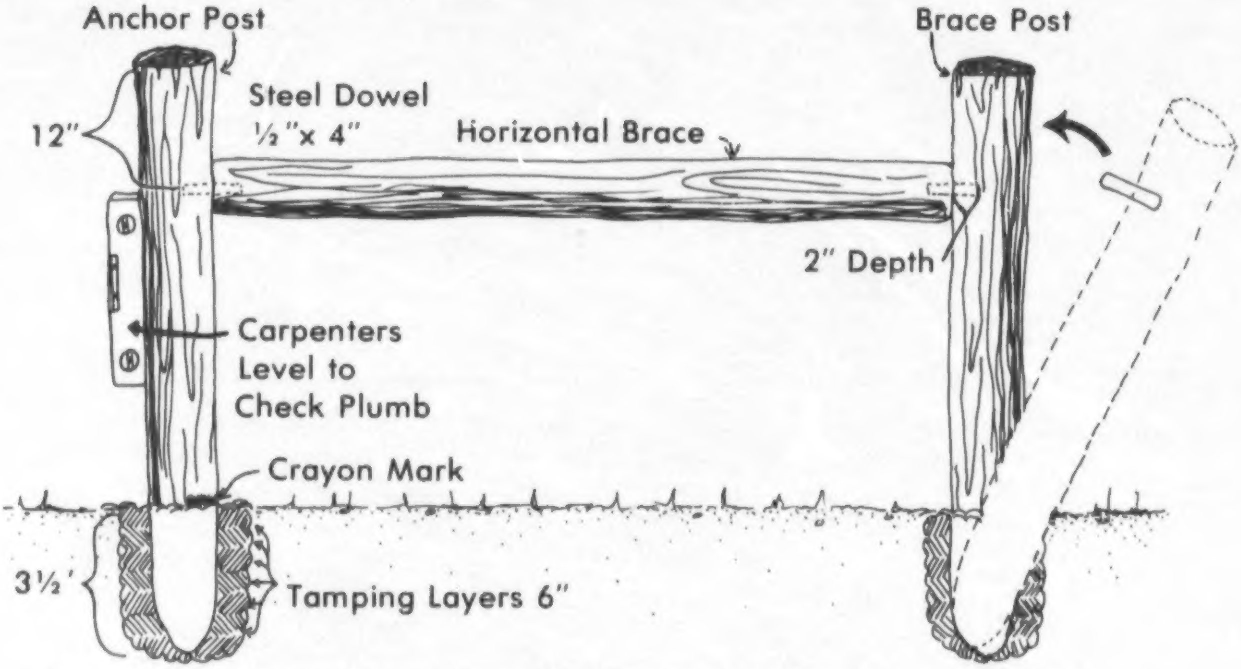
Step 9: Insert the 4-inch steel dowel into the anchor post to the depth of 2 inches.

Step 10: Install the horizontal brace member on the anchor post so that the steel dowel is 2 inches deep in the brace and flush with the post (deepen the holes if not flush). Using the carpenter's level, position the brace so that the horizontal brace is parallel to the ground. Using the crayon, mark the spot where the hole in the brace member contacts the brace post.

Step 11: Bore hole in brace post (Step 7) and insert the dowel (Step 9).

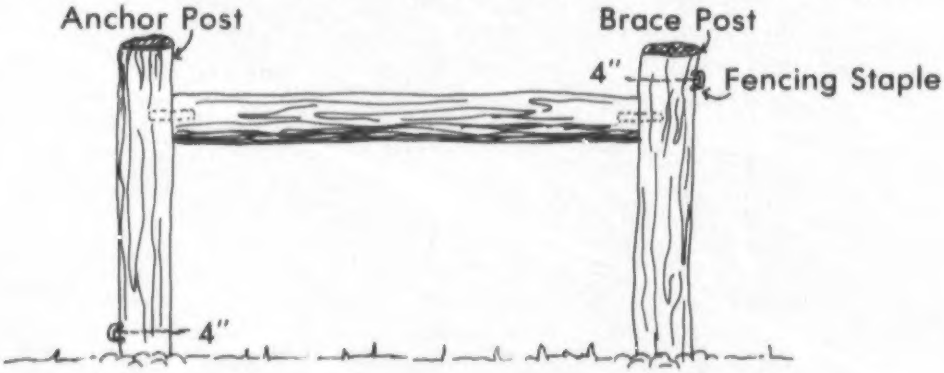
Step 12: Tilt back the bracepost and bring up the brace member so that the dowel inserted in Step 11 enters the hole in the end of the horizontal brace. Level the brace post with a carpenter's level and replace the soil around the base of the post. Tamp in layers, using the rod and spud.

NOTE: If the fence is over 40 rods in length, another brace post and horizontal brace member will be needed on the opposite side of the anchor post. To install, repeat Steps 4 through 12. For corner assemblies, it may be necessary to set the anchor post in concrete due to stress received by pulling action.


Anchor Post
Brace Post
Steel Dowel
½"x 4"
Horizontal Brace
12"
2" Depth
Carpenters
Level to
Check Plumb
Crayon Mark
3½'
Tamping Layers 6"

Step 13: Brace wire adds strength to the assembly if it is installed properly. The first step in this process is to drive a fencing staple to half its length 4 inches above the horizontal brace on the opposite side of the post from the brace.

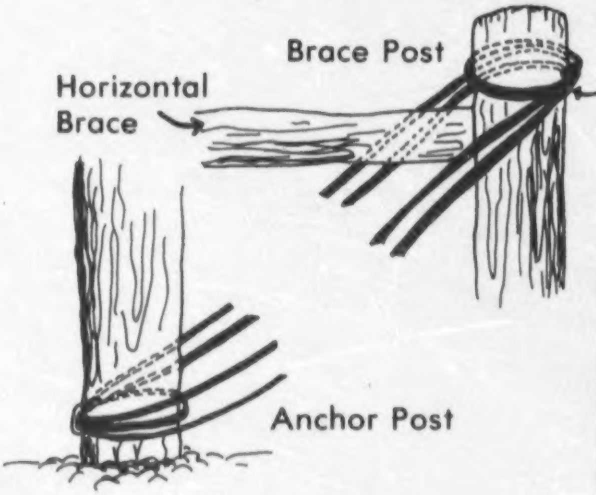
Step 14: Drive another staple into the anchor post 4 inches above the ground on the opposite side from the brace.

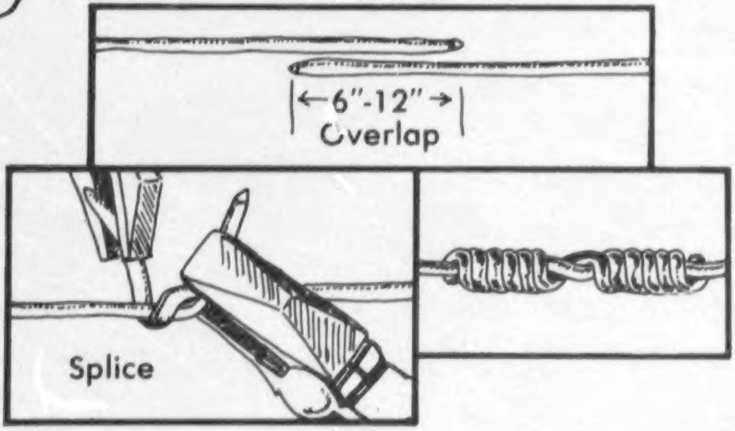

Anchor Post
Brace Post
4"
Fencing Staple
4"

Step 15: Measure the distance between the staples and multiply by 4.5. This figure is the length of wire to be used for the brace wire. If cord is available, use it to measure the distance--two complete loops between the staples.

Step 16: Thread the bare ends of the brace wire through the staples to form two complete loops around each post. You should be able to count four strands between the posts. On the last loop, wrap the bare end around the post before returning to the other post. Do this on both posts with the separate ends.

Step 17: When the two bare ends meet, they should overlap a minimum of 6 inches, preferably 12 inches. Splice the overlapping ends together using the wire splicers or pliers. Perform a western union wire splice for strength.


Brace Post
Fencing Staple
Horizontal Brace
Anchor Post


←6"-12"→
Overlap
Splice

Step 18: Using a stick or short pipe (18 to 24 inches long), twist the brace wire until the whole assembly is rigid. DO NOT OVERTIGHTEN AND BREAK THE POST OR WIRE!

NOTE: On fences with two spans that are over 40 rods long, double brace wires are recommended for added strength. The wire should form a "X" between the posts.